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TYPES OF BRITISH PLANTS

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The Library for Young Naturalists

EDITED BY F. G. AFLALO

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BY H. A. BRYDEN. ILLUSTRATED BY E. CALDWELL

"It will be welcome news to boys who are fascinated by wild life that the second volume of 'The Library for Young Naturalists' has made its appearance. . . . The author's manner is engaging, and he gives just the kind of information that is wanted by the lover of animals."—*Morning Post.*

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The Library for Young Naturalists
EDITED BY F. G. AFLALO, F.R.G.S., F.Z.S.

TYPES OF BRITISH PLANTS

COMMON SWISS THISTLE.

Frontispiece.

TYPES

OF

BRITISH PLANTS

BY

C. S. COLMAN

LIBRARY
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BOTANICAL
GARDEN

WITH 16 FULL-PAGE PLATES BY EVA AFLALO

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LONDON

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EDITOR'S PREFACE

THESE little volumes have been planned to fill what is thought to be a gap in modern Natural History literature between the more advanced manuals for adult readers and the one-syllable picture-books of the nursery. As a matter of fact, the keenest students of Nature at first hand are probably boys, who do not want to be insulted by the one or puzzled by the other.

While every attempt has been made to avoid all purely technical matters, and to explain any term not in everyday use, the authors have by no means affected the extreme simplicity of argument adopted in so many works of the kind. At the same time, the Editor will be only too glad to give any further explanations in his power, or to correspond with any readers on subjects of sufficient interest in which they may find difficulties.

OCT 24 1927

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TYPES

OF

BRITISH PLANTS

CHAPTER I.

INTRODUCTORY: CLASSIFICATION

In this little book I shall endeavour to give a general introduction to the study of plant life as a whole, paying special attention to that less conspicuous part of the vegetable kingdom, the cryptogams. My aim is above all to bring out the fundamental unity of plant life, and the continuous development from the highest to the lowest stages. That the work has no possible claim to originality will be obvious from a glance at its pages. I have endeavoured to take my information from the best sources, and, where possible, to test it practically. In the system of classification and arrangement I have followed the text-book of Professors Prantl and Vines, and hope that any boy who may become interested in botany will find that this book may make his study thereof more easy.

I have deliberately avoided, so far as possible, the use of technical terms, not in the least because the value

was not felt of a vocabulary which is at once brief, precise, and accurate, but because, until some acquaintance has been made with the classics, to recall the meaning of the terms requires a dreary and mechanical effort of memory. It would be a cause for serious regret if the new and just demand for an extended teaching of science were to lead to a neglect of the classical languages upon which true education must ultimately be based.

In the fear of dimming the general outlines I have tried to avoid giving exceptions. Until the main characteristics and rules of a group have been thoroughly grasped, it seems useless to insist on the exceptional peculiarities of eccentric individuals.

I want to ask those who may read this book to refuse to accept anything in it as certain which they themselves can test. I do not mean, "Refuse to believe that it is true," but go yourselves, when you can, and try the question fairly on the actual plants. With an ordinary microscope of a low power, or even with a pocket magnifying-glass, you can test the truth of what I hope to tell you, and the information you may thus get for yourselves from actual experience is worth much more than any number of facts merely taken from a printed book. I would have you test all you can by practical experiment, not only statements here, but any popular beliefs that you may come across from time to time; for instance, such a widespread belief as that primroses, if planted with their leaves downward and their roots upward, will come up with mauve flowers. It is not of much use to make experiments with flowers that are supposed to bring ill luck, such as blackthorn, for one

case where bad fortune followed would be sure to outweigh a hundred where nothing happened, and though you might convince yourself of the falseness of the story, you would not influence those who held the belief before.

Another idea I want you to keep constantly before you is the essential unity of all plant life. When one studies individuals separately one is apt to see only the differences, and forget what they have in common, but *both* sides are of equal importance to keep in view. The great glory of Charles Darwin was that he insisted on this close connection, and constantly endeavoured to look on Nature as a whole. The chief interest of Natural History lies in watching the development from a lower form to a higher, and tracing the first appearance of a new function or instrument in its simplest form, which is afterwards to become of the highest importance. From the oak to the mushroom, and even lower, to the microscopic plants, such as yeast, there is a ladder of descent in which, it is true, many rungs are missing, but by passing along which we may come to a better understanding.

Again, we shall see how the whole group of plants of every kind have close relations with the rest of nature. All animals depend on them, directly or indirectly, for their nourishment, including ourselves. It is only plants that can take up sufficient food from the earth. We must either eat vegetables or animals, such as cows and sheep, that in their turn have eaten them, and have made them into flesh. Without flowers, also, we should have no butterflies and no bees, none of our fairest insects, for they are dependent on the honey, and in their turn, as we shall see later, they are necessary to the flowers for the securing of seeds.

Now, the first necessity for the study of any subject is to decide on some arrangement or classification of the various individuals which it includes. You may say, "But why bother us with that; why not take up those that are specially interesting by themselves?" Well, let us take an example of what would be the result. Imagine trying to teach a school of two or three hundred boys without arranging them into forms. Of course it would be impossible, and so they are grouped into various divisions according to their knowledge. That is the great principle of their classification, and we want to find some principle which will serve us, in the same way, to group plants. Perhaps the most obvious difference at first sight is that of size. We might divide plants into trees, shrubs, herbs, and "planticulæ" (on the analogy of animalculæ), but there are objections as obvious as there would be to arranging school forms on the same principle. For instance, the common groundsel, which we know here as a little wayside plant, has a first cousin in Eastern Africa which grows into a tree. The puff-ball, which one meets in English fields, varying from the size of a marble to a small football, has a cousin in America which may be six feet in diameter, and one finds fossilised in coal mines gigantic mosses which once grew over England to the size of big trees.

What, then, is the principle which is adopted? Plants are put in a higher or lower "form" according to the extent to which they have adopted "division of labour," that is according to the extent to which the various parts have become altered and "specialised" for various duties. In the lowest "form" we find plants consisting of one single cell or compartment, which performs all the various functions required, but in the highest class we find part of

the plant has taken the peculiar form of a root, part of a leaf, and part of a flower. Now those of the later type, with more variety, are considered the top form. To take another illustration, the lowest type might be represented by a mass of iron ore lying in a mine. This reaches a higher stage when it has been through the blast furnace, and part has become, say, pig iron, and part a bar of steel. And a higher stage still is reached when this bar of steel is broken up, tempered, and ground until its various parts have been developed into a box of surgical instruments, each perfect for its various use. So we can find examples among plants of every stage, from the single cell, or mass of uniform cells, up to the complicated structure of the clematis, with its branching roots, its twining stem, and its gorgeous purple flowers.

Now the great business in which all plants are concerned is reproduction, the effort to ensure that their kind shall not die out, and the most important specialisation is devoted to that. This is the first point at which we look when arranging our groups, just as at many schools a boy's place is chiefly settled by his proficiency in Latin and Greek.

But when we have got our system of classification, there is a fresh danger against which we must guard. We must not look on these class boundaries as something fixed by Nature which cannot be passed. On both sides we find cases which seem in part to belong to one class and in part to another, and various botanists, looking to one point or other, argue for raising or lowering the plant, just as masters may argue for moving up a boy or keeping him back according to his progress in their particular subject. Nevertheless, though there may be no real gap between the top boy in the upper

fourth and the bottom boy in the lower fifth, yet the general type of each form is absolutely distinct. One is endeavouring to translate Virgil, while the other is content to wrestle with Cæsar; quadratics are the highest goal of one, while the other looks, possibly vaguely, at indeterminates.

This, then, will be our general system, but for special purposes we shall occasionally have a cross-division, just as a football fifteen or a cricket eleven may be selected from any form, and we shall have to deal separately with carnivorous plants, with parasitic plants, and with forest trees.

In our *lowest* class we have those plants which consist merely of a group of cells, or even of a single cell, which have no roots, nor any stem nor leaves, and which have no alteration or combination of the cells into the vessels and fibres which are described in Chapter III. Into this class come an enormous number of plants (many of which are microscopic), namely, the seaweeds and pondweeds (such as the green scum over a stagnant pond), and all the fungi. (See Chapters VI. and VII.) Their methods of reproduction are very simple and primitive.

In the *second* group we reach a higher stage, for we now meet with a real stem and leaves. This group includes the mosses, but as yet no roots have been developed, nor have the fibres and vessels, which may be compared to our bony skeletons, as yet appeared. Amongst plants the mosses reach about the same stage as the earthworms among animals. As we shall find in Chapter VIII., their method of reproduction becomes more complex, and special organs begin to be set apart for it.

The *third* group, that of the ferns, comes very near to the ordinary plants we know so well, for the vessels and fibres are now well developed. They have obtained their skeleton, they have fully-equipped roots and leaves, but they have not yet reached the stage of producing seeds, which are complete plants in miniature.

Now we reach the *fourth* group, that of the flowering plants. All of these have flowers, generally fairly conspicuous, and they produce seeds which enclose within them rudimentary stem, roots, and leaves.

In one or other of these four great groups are arranged every one of the plants, and though occasionally one or two individuals may seem to belong half to one and half to the other, their general distinctions are plain enough.

These classes, however, are still too large for convenient working, and must be further broken up. In Class I. we have already separated seaweeds and funguses. For the present it is sufficient to note that the first are always coloured with chlorophyll, a substance we shall see more of later; the second never.

In the moss class we may separate the liverworts (Chap. VIII.) from the mosses proper, and in the ferns (Chap. IX.) the horsetails from the ferns proper.

When we come to the flowering group, we make a great division, according to the way in which the seed is kept ready for fertilisation. Among the pines and firs (Chap. XI.) the seed lies open and exposed, but the rest of the flowering plants have developed one step further, and guard it in some kind or other of seed-vessel.

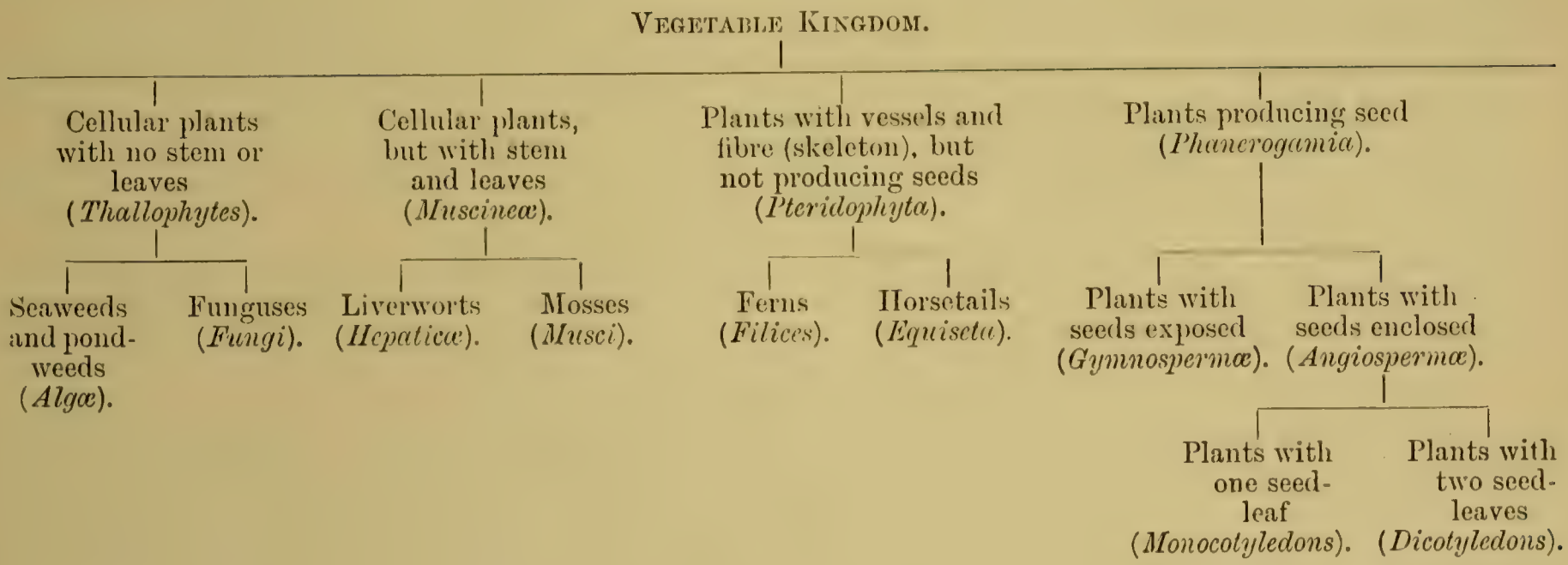
This still leaves us with an unmanageable number of plants with a closed seed-vessel, and they are further

divided according to the character of the seed. One group has only one embryo leaf in the seed, and the other has two. This seems a very small point by which to classify, like making up a form by the colour of the boys' eyes; but we shall see later on that certain striking differences are to be found in all the plants that come from these seeds with only one root-leaf or *cotyledon*.

Here, then, is a skeleton table of the classification, with the scientific names of the various groups. If you can remember these names, so much the better, but it is a good deal more important to remember the characteristics of the various groups, and the reasons for so arranging them.

Before we go farther with particular plants or types of plants, it will be best for us to look into the essential parts of all plant life, to find out what we can about the "cell" which is the foundation of the plant, and of the vessels and fibres which appear as soon as we reach the higher forms. Then, when we have seen what we can of their structure, we shall be able to see the plant at work, using these various implements, making the best fight it can for a comfortable life, and always trying to ensure that there shall be plenty of descendants who shall carry on the battle of the race (Chapters II.–V.).

TABLE OF CLASSIFICATION.



CHAPTER II.

THE CELL AND ITS CONTENTS

All the plants in the world, from the Cedar of Lebanon to the Hyssop on the wall, and down a good deal farther yet to the lowliest moss, or fungus, or seaweed, are built up little by little from *cells*, modified in all manner of ways, but yet all possessing certain common elements, which I will now endeavour to describe. Some of the lowest plants, as you have already been told, consist of but one cell, whereas an oak tree may contain millions upon millions, changed a good deal, some of them, but still recognisable under the microscope as possessing, or as having once possessed, the essential characters that are common to all.

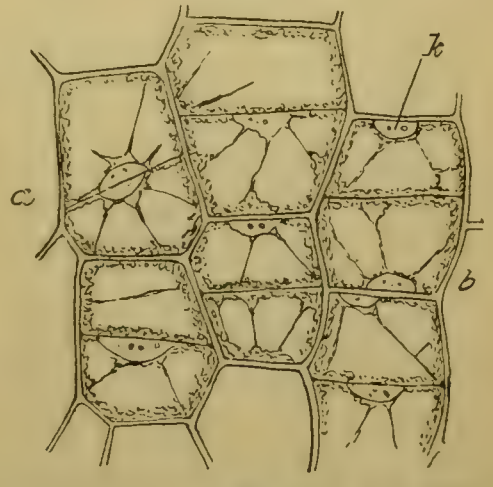
We may look on every plant as a factory, some busily working night and day, but most only active in the sunlight. In Chapter IV. we shall see how the factory works. For the present we will consider it as standing still, and examine the machinery and the material that the plant is working up.

Put in its simplest form, a cell is a small ball or box full of jelly, and this is the form taken by most of those single-celled microscopic plants which form the lowest class of funguses and seaweeds. But both shape and size may vary enormously. When cells are growing together

in a tissue, each pressing on the other, they tend to form cubes, or similar shapes, and such cells you can see with the naked eye in the pith of the elder, or in the fruit of the snowberry. Others, again, grow long and thin, and fit into each other like the fingers of your hands, if you put the nails of each down to the roots of the fingers of the other, and each type has its separate work to do. The size may vary in just the same fashion. A very ordinary-sized cell would require 300 of its brethren in a line to spread over an inch, but some can be seen with the naked eye. Others, such as the hairs on the outside of the cotton-seed, may grow to an inch or two, and some of the seaweeds or algæ, where the whole plant is only one cell, may grow to a good deal more.

Let us, however, take a young cell, which has not yet taken any special shape, and under the microscope see what we can make of it. We find a firm membrane, and inside it a jelly-like substance. That is all we should be certain to find; but if the cell were from one of the higher plants, we should also notice that the jelly seemed to be a little thicker in one part than in the rest.

This outside cover, membrane, or *cell-wall*, is composed of just the same substances, and in the same quantities, as starch and sugar, although it does not look like either, and the atoms of carbon, hydrogen, and oxygen that go to make it up, must be in some way differently arranged.



Cell divisions in the outer skin of the growing stem of *Vicia Faba*, × 300. At *a* the division has just taken place, the nucleus *k* still adheres to the new wall. At *b* it has retreated to the older wall.

The material is called *cellulose*, and the only agency that can make it is the jelly inside. This wall is just the workshop building, and the workman is the jelly inside. This is proved by the fact that the wall without the jelly is dead, but in the lower plants we can sometimes see the jelly go out from the cell, and build itself a fresh wall elsewhere.

Before we go further and examine the various alterations that this wall may undergo, we must know something more (nobody knows very much) about this extraordinary jelly that can build up plants. The name given to it is *protoplasm*, and it looks like raw white of egg. Now wherever life is, whether in yourself, in other animals, or in plants, this jelly is found, nor is there anything known which can make it but protoplasm itself. No chemist, for instance, has yet made it in a laboratory, and by this jelly, in some way or other, are built up all the living things whose study we know as Natural History. It is the colourless and transparent basis of all life.

As to its composition, it is almost entirely made up of three common gases, nitrogen, oxygen, and hydrogen, and the common solid carbon, but there is always a trace of sulphur and of certain other minerals.

This jelly lies on the cell-wall and steadily builds it up, putting in fresh material in the interstices, and thereby stretching it until it reaches its full intended size.

Now let us go back for a moment to the cell-wall, and see what may happen to it. It may take up two modified forms, both useful to a plant in many ways. The wall may become hard and woody, giving strength and toughness. This is called *lignification*. Or it may become cork, and then it is impenetrable to water. A covering

of such cells to a plant acts as an overcoat in the winter, and in the summer it prevents the heat from drawing away too fast the water which is the plant's life-blood.

Further, if we examine cells of all kinds we shall find that in many the wall is greatly thickened to bear the strain of winds or the weight of the plant itself. One minute cell would have of course no effect, but when in thousands of these workshops side by side the same task is going on, you will see how rapidly a plant may be strengthened. In some cells the wall is not thickened everywhere, but circular or spiral rings are drawn around it on the inside, or, sometimes, the protoplasm forces material through and builds up ridges upon the outer surface of the cell, all in accordance with the unseen wonderful design.

These two elements, the wall and the jelly, are all that we can be sure of finding in every living cell, and we can now pass to features which we *may* meet.

In all the cells of the higher plants there is a thickening of the jelly at one point, and this is called the *nucleus*. What its functions are we do not know, and all we can say is that important changes in the cell are always first indicated in the nucleus, *e.g.* when the cell is about to divide. One may perhaps consider it as the foreman of the workmen in that particular workshop.

We now come to the most important machine in the plant factory, and this is to be found in the cells of practically all the green parts of a plant, especially in the leaves. Round the edge of the wall we see little patches of bright green protoplasm, and these are known —and the names should be remembered—as *chlorophyll corpuscles*. The word chlorophyll simply means "green leaf." In Chapter IV. we shall see these corpuscles at

work. Here we need only notice that they are ready. Corpuscle, by the way, is a small body, a long word for a diminutive article.

As the cell-wall expands—and how fast they expand you will realise when you remember that *every* cell in a full-grown leaf was also present in the bud, and each cell has to grow as the leaf expands—the protoplasm which once filled it now only lines it, and the interior is filled with the cell sap, chiefly water, but containing various substances, such as sugar and starch, dissolved within it. This sap acts as the carrier from one workshop to the other, for the cell-wall has the property of allowing it to pass through, and is thus useful to the plant. From the sap of various plants, such as the sugar-cane, the sugar-maple, and the beet, we get sugar.

Looking through more cells we may notice, in the chlorophyll corpuscles, certain grains of another substance, *starch*, which is being formed as a reserve store of material for building up new cell-walls when required.

STARCH GRAINS MAGNIFIED.

If we also examine, say, a seed, or a slice of potato, under the microscope, we shall find in certain cells quite large grains of starch, all ready for the next year's sprouting. In some trees, such as the sago-palm, this is stored in such quantities in the pith that with very little preparation we are able to eat it in sago and tapioca puddings.

Beside this reserve, there

are also to be seen stores that will go to the building up of future protoplasm, and these are called *aleurone-grains*. These are chiefly to be found in seeds. With them may also be sometimes seen little round bodies called *globoids*, which consist of double phosphates of lime and magnesia.

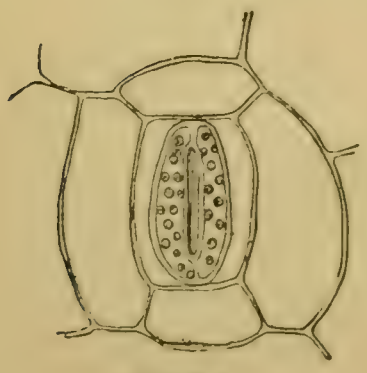
In a few cells one also finds mineral crystals, whose use or value is unknown. A probable suggestion is that these crystals are just a convenient form of rubbish heap for materials which the plant has taken up from the earth, and for which it has no use.

Before we consider the factory at work we must try to understand some of the more complicated structures into which cells develop in the higher plants. Seaweeds, funguses, and mosses are content with the cells alone, but the ferns and the flowering plants begin to build up that arrangement of vessels and fibres, or *fibro-vascular system*, which I roughly likened above to our own skeleton.

CHAPTER III.

VESSELS AND THE "BUNDLES": WOOD, CAMBIUM, AND BAST

We may now turn to the higher plants and consider their more elaborate factories. The bulk of the living part of such plants still consists of our ordinary cells, but we have now, so to speak, three elements to study, which correspond in a way to our own skin, flesh, and bones. The flesh we discussed in the last chapter, but a few words may be fairly in place about the skin. All plants that have anything like a complex organisation, *i.e.* all plants that rise above the single cell, or the single layer of cells, begin to feel the want of a skin, and they clothe themselves with a single layer of cells, usually colourless, and fitting closely together all over the plant. This skin you can tear off for yourselves from almost any leaf, and you will see that it is a transparent membrane covering the green chlorophyll cells beneath. It seems to be, as I said, continuous, but if you look at it with a low-power microscope you will see there are small holes or mouths in it (*stomata*). These serve the purpose of the pores in our own skin to some extent, for they allow the water to evaporate when the plant on rare occasions has more than it wants,



STOM I.

and what is more important, they serve as mouths to breathe in the air which, as we shall see, is necessary for the proper working of the plant factory.

So far as the leaves are concerned, these skin-cells can grow sufficiently for one year, but the skin-cells on the branches and twigs are in a different position. They cannot go on stretching indefinitely, and they have lost the power of dividing themselves and so filling up the gap. The result is that the epidermis, or outer skin, on the twig splits, and the living part below is exposed. To meet this difficulty the cells just below the epidermis begin to split with great vigour and divide as fast as they can.

But this time they do not make epidermis. They push out layer after layer of cells with the ordinary kind of wall changed into cork, and fill up the gaps. This is the reason why, on any bush or tree, the twigs after a little while turn brown; the cork has taken the place of the epidermis. It lets no water or nutriment pass through it from inside, and so everything outside of it dies and begins to form bark. As you know, bark is quite dead matter, and some trees, such as the plane, shed it every year. In some trees, on the other hand, the cork is produced layer after layer, until you get masses of layers, such as are borne by the Cork Oak. Here also all the outside layers are dead, and it is only the inner actual cork-*growing* layer that can be harmed. All this cork acts as a great-coat for the tree, but the plant would be uncomfortable if it were not ventilated. It therefore forms small openings in the layer, and in these openings the cork-cells lie very loosely, so that the air can pass in easily. A most interesting point is that in winter these openings are closed at the base by a specially

tight-packed layer of cells, but as soon as spring comes the layer is split and the air can come through again.

A very good example of this cork jacket is seen in the rind of a potato, which is not really a root, but a thickened underground stem. If you cut off a slice of the rind, leaving the white surface exposed, the living cells underneath will set to work and make brown cork-cells which will soon cover the whole of the exposed surface.

I am now free to deal with the question of the vessels and the bundles, and, as this is perhaps the most difficult point to make clear, I must for a moment have your special attention.

In the first place, what is a vessel? Remember this: it is not just an overgrown or elongated cell, but it is a combination of a whole long row of cells. Imagine a row of the boxes to which cells were compared placed side by side in a straight line, and then the sides of the boxes slowly disappearing, or being absorbed, until the boxes had become one long tube, running, in many cases, the whole length of a plant. Sometimes, instead of the partitions disappearing altogether, they are merely perforated with many holes like a sieve. It is not worth while here to go into all the different kinds of vessels, the use of some of which we do not know. Some conduct air, some water, and some sap about the plant, far more quickly and effectively than the cells could do it, when the material wanted, air, or water, or what not, would have to percolate through the cell-wall. In some plants, such as the Dandelion, there are also vessels which branch in all directions, and are full of that milky juice which you will see oozing out from a broken Dandelion stalk. This white juice is very often useful to mankind, as you will believe when you know that indiarubber is

obtained from these vessels, and opium also from the seed vessels of a kind of Poppy.

In the higher plants the long tubes, whose formation we explained, together with many elongated cells, are collected into "bundles," called specially *fibro-vascular* bundles, and a typical bundle is composed of three elements—wood, cambium, and bast—arranged thus:—

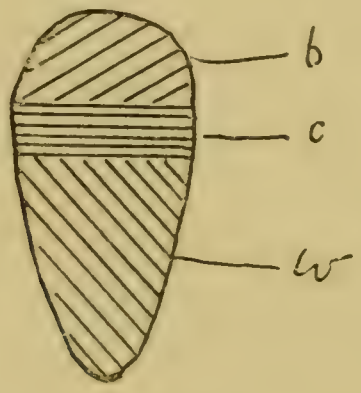


DIAGRAM OF BUNDLE.

b. Bast. *c.* Cambium. *w.* Wood.

Bast may be simply described as the fibrous inner bark, while cambium is the layer of cellular tissue in which the growth of the bark has its origin. Before we go any further, let us clear up one point. These bundles exist in all flowering plants, say, for example, in the daisy and the buttercup. Yet you will say that there is certainly no wood at all in such plants. That is true in a way, but the ordinary wood, as we know it in the trunk of a tree or in a plant, is really made of the woody part of innumerable bundles, tightly packed together as the tree grows. In every leaf of a tree there is a certain amount of wood material, but it does not become conspicuous until we have a large number altogether.

One thing always to be kept in mind is that what

we call the veins of a leaf are really the extreme ends of these bundles, which run up to the very tips, giving strength to meet the wind, the vessels also acting as conductors to and from the leaf-factories. From the spreading leaf they run down the stalk and into the stem. If you take a leaf of the ordinary plantain, which you may find, unfortunately, killing the grass on nearly every tennis lawn or cricket pitch, and pull the leaf-stalk in two, you will find that there are pale threads, very tough, hanging from one of the broken pieces. These are the bundles hastening down to join the stem, and under a strong magnifying-glass you would be able in a cross-section to see the three elements, wood, cambium, and bast.

The wood section consists chiefly of small cells with hardened walls and a few large vessels, generally with deeply-pitted sides; the bast section contains some of the sieve tube vessels which we mentioned, and some tough fibres, which in trees form the bast which we use. Beyond the bast generally lies a row of cells which is called the bundle-sheath. These cells are usually a rich reservoir of starch grains.

In between the wood and the bast sections comes the all-important *cambium* layer. From this layer both the other sides spring, for its cells are continually splitting, sending off on one side cells to form wood and its vessels, on the other cells to form bast and its vessels.

You will remember that, when we were talking of classification, the number of leaves in a seed seemed hardly sufficient difference to mark off a class (p. 8), but that other and very important differences went with it. One of these differences arises over the question of these bundles. The Monocotyledons (plants with only

one seed-leaf) have bundles like the rest, but they have little or no "cambium," that is to say, the cells very soon stop splitting up, and there are only the wood and bast sections left. The bundle is then said to be "closed," and if the tree or plant is to grow another bundle has to be started in the "fundamental tissue" or mass of ordinary cells, such as we described in Chapter II. Now in the Dicotyledons the bundle remains "open," that is to say, the cambium cells go on splitting and splitting so long as the plant continues to live.

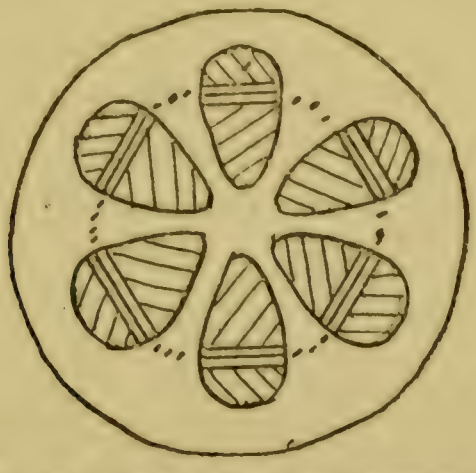


DIAGRAM OF CROSS SECTION OF YOUNG TWIG.

I want you now to see how these bundles go to work in building up a big tree.

Let us take the stem of a two-year-old seedling tree and cut a cross-section. We shall find a few bundles embedded in the flesh, say, four or five, each with the woody part towards the centre, a narrow band of cambium cells, and then the bast part outside. But while the cambium is building up wood towards the centre, and bast towards the circumference, it is also forming cambium cells at its own free edges along the dotted line in the figure. These new cells, in their turn, busily construct wood on the inside and bast on the

outside, and in a year or two we have roughly three concentric rings. Outside is a ring, or hollow cylinder of bast; next to that is a busy ring of cambium cells; and behind this is the solid mass of wood, projecting into the pith with which nearly the whole stem once was filled.

Year by year the process goes on, only, now that the bast is complete, almost the entire energy of the cambium goes to building up the wood with layer on layer of cells. All the protoplasm speedily goes from these cells. They will grow no more, and only serve to carry water or air about the plant or tree, and to give it strength. This is why a hollow tree lives so long. The wood that has gone, though probably useful, was in no way necessary to its growth, and the tree can manage very well without it. On the other hand, we can see how it is that trees can be destroyed by "girdling," as it is called, a method in use when it seems too much trouble to cut a tree down. A cut is made completely round the trunk, not very deep nor very wide, but, like Mercutio's wound, 'twill serve. The dead bark matters nothing, but if the thin bast layer and the cambium ring are cut the whole of the plant must die.

The age of a tree can, as you know, be counted accurately from the number of rings that show upon the severed trunk, and the reason of this is somewhat curious. The apparent ring marks the junction of the new wood of spring with that formed in the previous autumn; but one may ask why there should be any obvious difference. The reason is that the cambium ring, which is always building up its wood-cells towards the centre of the tree, makes much larger cells in spring than in autumn. In winter, of course, the building stops

altogether. The spring cells are larger than the rest for two reasons—first, there is more sap running in the tree, and the cells fill out better; and second, the jacket of

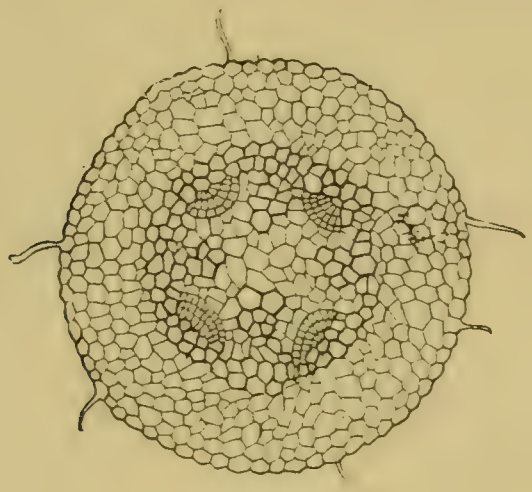


DIAGRAM OF ROOT.

bark has been split with the winter cold, and stretches more easily. Towards the autumn it has grown hard and dry and fits more tightly. Under the pressure all round the new wood-cells are more tightly packed. Then comes the winter's rest and next spring more large-celled wood, the edge of which shows up distinctly against the autumn ring.

In the root the bundles very early form one central mass, the woody and bast sections inside, the cambium ring jacketing them closely, and giving rise to all the various side roots that spring out and help the plant by extending the area from which it gets its food-supply.

CHAPTER IV.

HOW PLANTS LIVE AND GROW

We have seen something of plant arrangements when the machinery is, so to speak, standing still, and we ought to be able to understand better the actual processes by which they live. Now with plants, as with animals, and perhaps even with human beings, the question that first arises is, "How can I get something to eat?" The nourishment that they want is not found in the proper shape either in the earth or the air, and there are two ways out of the difficulty. They must either make the proper food or live on something that has made it already. Now animals and men feed either on plants or on animals that have fed on plants before, and their example is followed by a large group of plants, namely, the funguses, of which we shall have more to say later, and a few "parasitic" flowering plants.

Most plants, however, make their own food, and we shall see the method best in a large plant, though the principle is the same throughout. If we take an oak tree, we find that it has two sources of nourishment, the leaves and the roots.

By means of the first it takes in carbonic acid gas, which, as you probably know, is always present in fair quantity in the air. It also takes in by the leaves oxygen

from the air. This oxygen it wants, like all other living things, to breathe, and without it the protoplasm, for some reason we do not understand, would not have the energy to carry on its digestive and its building work.

The roots, meanwhile, have to find all the other nutriment required, and, above all, they are diligently pumping up water, which is made up of the two gases, hydrogen and oxygen. Each little root is covered with small hairs, which cling to the particles of the soil and suck up the traces of moisture that they can find. In addition to this, by the help of the acid in the sap, they are constantly dissolving various mineral compounds of sulphur, potassium, lime, and so forth, which are always present in a soil suitable for plants, and pumping up certain quantities of these for the making of the necessary *protoplasm.*

A pretty experiment, showing the acid properties of the sap, is to allow the roots of a plant to spread over a marble plate just covered with earth. The roots bite quite into the marble, slowly dissolving it, and taking up the lime that they require. If the plant is pulled up afterwards, one finds a complete sunk pattern of the roots over the slab.

The various vessels in the bundles form ready passages for the material required, and the wood especially is an excellent conductor of water and air all about the tree.

You will remember that in the cells of the green parts of the plant, and especially of the leaves, we found that part of the protoplasm had collected into green bodies called chlorophyll corpuscles. These green bodies are never formed unless the roots are able to send up a solution of iron, but when once made they have most

important work. They seize on the carbonic acid, which comes in through the mouths, pores, or *stomata* of the skin, and break it up into carbon and oxygen. The oxygen they do not want for the time, as they can get sufficient from the water in the cell, so that is expelled from the leaf, but the carbon they keep, and combine with the hydrogen and oxygen of the water into starch or sugar. With the microscope one can see the starch grains forming in the chlorophyll. As you will remember, starch and sugar are alternative forms of cellulose, of which the cell-walls are made, and so from the leaves in one form or another this raw material is taken round to places where cells are splitting up fast, as for instance to the cambium ring inside the trunk. It is just as necessary where cells are not splitting into more, but merely growing lengthwise or having their walls thickened. In any case they want bricks for the wall, and the protoplasm gets the raw material from the leaves, changes it into cellulose, and then as it runs around the walls of its cells keeps putting little particles in, and either stretching or thickening the membrane, or, if the cell be dividing, building up a fresh party wall. Very often the starch grains are not used up at once, but are taken and stored in suitable places, as in the sheath around the bundle, in tubers like the potato, or in seeds, ready for next year's growth. Thanks to these stores, a potato in a cellar, without any soil, can go on merrily for quite a long time sending out a shoot, and building up the stalks as it goes along with cellulose taken from the reserve laid up.

Cell-walls, however, would be useless by themselves, and the living protoplasm must be nourished too. Besides the solid carbon, and the two gases, oxygen and hydrogen,

we now require a third gas, nitrogen. This is present in the air, but plants never get it from that source, always preferring to draw it up in compounds from the roots. The chief object of manuring is to ensure that there shall be plenty of these nitrogen compounds in the soil. With these three gases, carbon, and a few traces of minerals, especially sulphur, potash, and phosphorus, the protoplasm can keep itself going, and also form fresh reserves for the future in the shape of the *aleurone-grains*, which correspond to the starch grains for the cell-walls.

There is one curious point about the chlorophyll corpuscles which is worth remembering. *They only work in the sunlight*, and therefore at night plants no longer are giving off their spare oxygen. In the daytime, though they are always breathing oxygen, they are giving off far more than they are taking in, but at night they are simply using it up, and there is for this reason some ground for the belief that plants are not good in a bedroom.

All this work of the leaves is so important that you can see what a disaster it is for plants to lose them. A late frost in spring may nip any number of leaves and kill them, and the tree's growth for the year is heavily handicapped. Other leaves that were too closely in bud for the frost to get at them may enable it just to keep alive, but the cambium cells will be checked in their splitting, and very little new wood comparatively will be made. If it be a small plant with all its leaves unfolded, the failure of the starch department will often lead to its entire collapse and death. You might bear this in mind when next you feel inclined to pull the leaves off any bush by the wayside. It can give you small pleasure, and it handicaps the plant very seriously.

Just the same kind of harm is done by the caterpillars, which clear whole branches, as you may see on lime-trees where the long green buff-tip caterpillar has been at work. This is not quite so fatal, for in the first place the whole tree is not usually attacked, and in the second the devastation is not generally serious until the summer, when the leaves have already been able to do a great part of their year's work, though you may often see a gooseberry bush dropping its fruits, the leaves being too few to feed them.

Various interesting devices have been adopted by plants to preserve their leaves. In many the leaf-buds are shrouded when young by thick, scaly, overcoat leaves, such as one may see in the horse-chestnut. Some, such as the elm, appear to have a bitter taste, and hardly any caterpillar will come near them. Many shrubs, in order to protect themselves against browsing cattle, are armed with stiff thorns, such as are found on both hawthorn and bramble. Others, such as the furze or gorse, have all their leaves modified into spiny and prickly shapes; the nettle arms all its leaves with stings, and the thistle fringes them with penetrating spines, which secure them incidentally from being sat upon for long by lazy human beings.

On the other hand, it is most interesting to note how the animals against whom they are preparing get themselves ready for the fray. We know how the donkey's mouth and throat have been hardened until he looks on thistles as a mere delicacy to tickle his appetite, and the giraffe has developed such leathery lips that he browses comfortably upon acacia-thorn, whose spines tear a man's clothing to rags if he tries to force his way through it.

This is a rough outline of the way in which a plant keeps itself alive. Some water-plants do without roots, and find all they want dissolved in the water in which they live. Seaweeds, for instance, even take their carbonic acid gas from the water, for there is a little dissolved in sea-water, and some flowering plants are content with only leaves and stalks.

Plants grow in two ways; either the cells expand or they go on dividing. We have seen how the walls are increased by the building protoplasm, but this process has its limits, and the chief method is for the cells, like those of the cambium ring, to divide themselves into two or more. The topmost point of a stem, for instance, builds itself higher by this constant splitting, and so does the lowest part but one of the root. The very end of the root is a mass of hardened cells, which do not continue to grow but act as a borer, and also as a protection for the tender growing part behind them.

When a cell is about to divide, the first noticeable feature is that the "nucleus," or thicker portion of the protoplasm, splits into two, or, if four new cells are to be formed, into four sections. Then a new cell-wall, or new cell-walls, will be rapidly built, and each cell may start dividing again (see illustration on p. 11).

In some of the lower plants the nucleus may divide into an indefinite number of nuclei, and, each with its surrounding little globule of protoplasm, all may be driven out into the surrounding air or water to build fresh walls around themselves, and to start as new individual plants.

It would seem, perhaps, that the power exerted by a mere jelly could not be very great, but the number of cells is so large that, when they work together, hardly

anything can withstand them. A mass of fungus, growing in a cellar, has been known to lift a large paving-slab from its bed, and plants, sown by the wind in a crevice of the wall, have grown and forced the stones farther and farther apart. There is one Indian temple which has been made unsafe in this way by a fig tree, sprung from a seed dropped casually on the roof, which threatens the safety of the entire structure. Just as wonderful, in its smaller way, is the muscular power, so to speak, with which the tender seedling forces on the top of its stem upwards through the earth, and drives its root-cap ever lower and lower, shouldering the hard earth aside.

As an illustration of the enormous power of a growing part, one may mention the effect of a root as described in Kerner and Oliver's *Natural History of Plants.*

"In the Tyrol there is a little valley strewn with large blocks of stone. On one of these blocks, at a height of two metres,* a larch has long ago established itself and rooted firmly, so that the strongest of its roots grew downwards in a cleft parallel to the direction of the mica streaks. By the thickening of this root the crevice became widened; half of the upper block was separated from the lower and raised about thirty centimetres.* It is estimated that the weight of this raised portion amounts to 1,400 kilogrammes,* and the root which was able to raise this burden exhibits in its thickest part a diameter of only thirty centimetres. Moreover, the burden overcome by this larch root is small in comparison with that raised by the roots of old trees."

It is by recalling how the trunk of a tree grows in

* Two metres would be equivalent to 2 yards 6 inches; thirty centimetres to rather less than one foot; and 1,400 kilogrammes to about 3,000 lbs. (Av.).

height and the lowest branch becomes farther and farther from the ground, and that this growth necessitates the actual lifting of the mass of boughs and branches and leaves above the point of growth, that we are able to realise the enormous power commanded by the joint action of these thousands and thousands of cells.

CHAPTER V.

HOW PLANTS SPREAD AND MULTIPLY

So far we have dealt with the efforts of the plant to secure its own living and the working of the individual; we may now turn to the various ways in which plants fight for the increase and prosperity of their families. Big as the world may seem, there is only a limited amount of suitable nourishment, and there is a vast amount of competition for it. Even in the individual fight one may see how fierce the struggle is. The grass on the tennis lawn is crushed out of existence by the invading plantain, its flat rosette of leaves hug close down upon the earth, and even the dandelions and daisies that decorate the lawn are crowding out the weaker turf, and in the flower beds the plants, unless the gardener comes to the rescue, would soon be choked by the more vigorous weeds that are constantly intruding, unasked and uninvited. Again, one may notice the bare soil beneath close-crowded trees. The trees cut off so much sunlight that the plants beneath have no outside encouragement to set in motion the machinery of their chlorophyll corpuscles. The trees themselves, if too closely planted, have to fight for the sunlight, and devote their energies to growing tall and thin, in order that they may overtop their fellows.

When it comes to a contest between whole families of plants, the competition is far keener. Just as we have to fight for our share of whatever work, trade, or practice there may be in a town, so plant fights with plant, and as nations have to compete for wider lands for their children, so do all the races of plants. But in the latter case the number of competitors is infinitely larger. Some plants have far more seeds than others, but we will take as an example the Henbane, a weed you may find in rich and damp soils, which has a comparatively small family. The number of the seeds has been carefully counted, and an average number of seeds for one healthy plant is actually ten thousand. The common shepherd's purse, by-the-by, which you may find anywhere by the wayside, rejoices in an average family of six times the size. Well, if all the ten thousand children grew up in the next year, and each repeated the performance, and so on, how long do you think it would be before every part of the dry land was covered with henbane plants to the number of sixty to the square yard? Just about five years, and no room left for any other flower. Of course this never can happen, because other plants are doing much the same, and nine hundred and ninety-nine out of every thousand seeds are killed by some means or other in the race, but you will see some reason for the various devices that are found in plants to secure a chance for their progeny.

It is not enough merely to have crowds of seeds, but they have to be planted some way or other in suitable soil if they are to find any prospect of survival.

There are two great ways in the vegetable kingdom of founding a family. In the first, the plant simply breaks off parts of itself in its own neighbourhood and founds

a little community, just as a town steadily grows within its own borders. But these devices never, or rarely, carry a plant very far from its centre, and the great method is to send out emigrants in the shape of seeds, as they are called in the flowering plants, or *spores*, as they are called in the non-flowering or "Cryptogamous" plants.

The first method is called "vegetative reproduction," and includes all the various ways in which offshoots may start a fresh plant. Perhaps the simplest is that which you may see in any strawberry bed. The long, straggling branches which gardeners call runners touch the ground at some distance from the parent root, and form at that point a little root of their own. Here a fresh plant springs up, working on its own account, and making for itself all the nourishment which it requires. Very soon the connecting branch withers away, and the young plant is quite independent, ready to send out fresh branches and found a new suburb.

Another very common way of spreading a family is illustrated by the Potato. During the summer the Potato Plant stores up in its underground stems, which we eat, starch and aleuron and other reserve materials. In the winter the parent stem which united and fed them all dries away, and there are eight or ten separate potato plants ready and waiting for the next year's sun.

Tree roots also sometimes assist in producing fresh individuals. At various points in the roots of an Aspen tree, for instance, a young Aspen may start growing up. When it is fairly established the root behind it feels that its work is done, and dies away. Cases are mentioned where a root has wandered thirty yards away from the parent stem and started a fresh tree, thus giving it a better chance of plenty of light and air. The roots of

TRAVELLER'S JOY.

Face page 34.

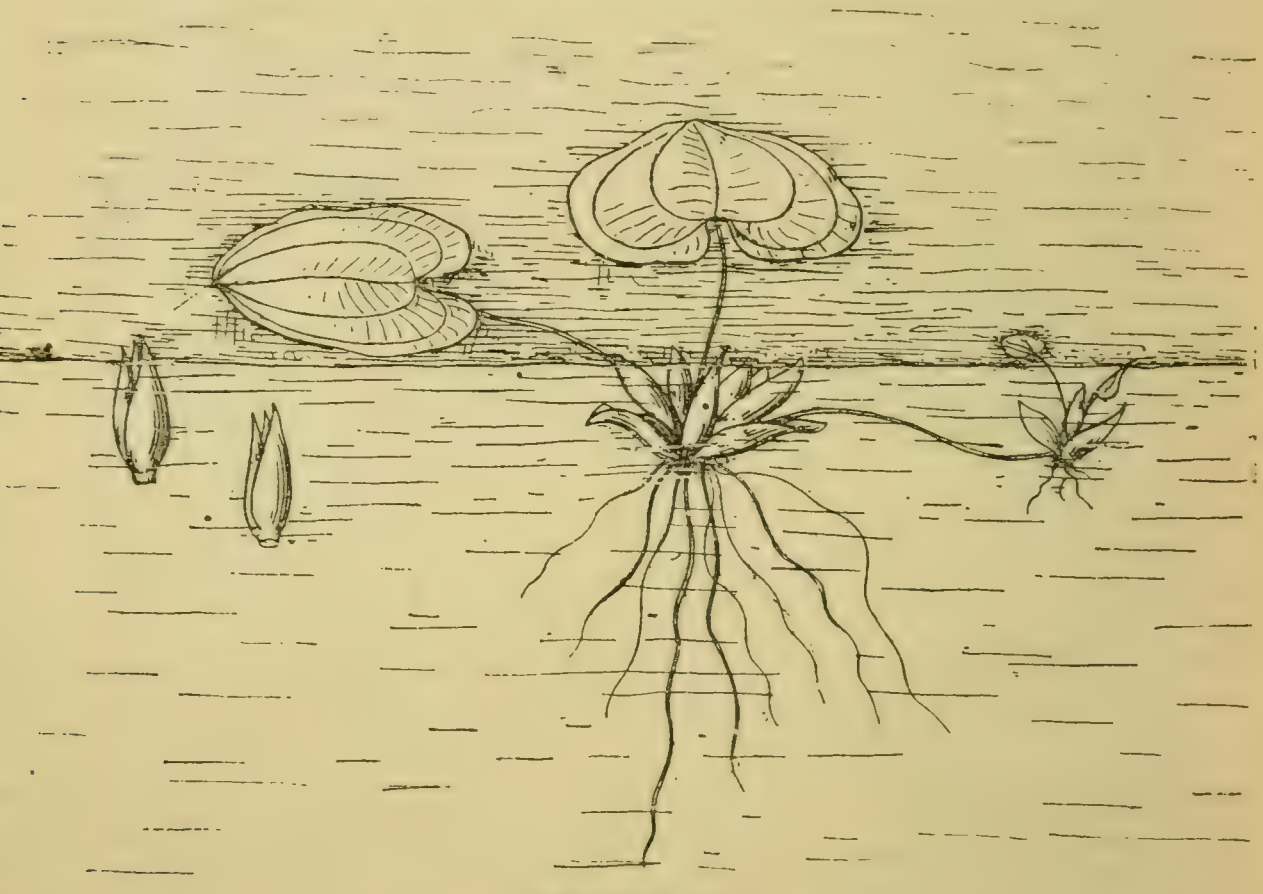
raspberries act in the same way, and, curiously enough, generally work in one particular direction. After a time the parent plant may die away, but the young ones proceed, and sometimes the whole group seems to dive beneath a fence to reappear on the other side.

It is by a growth of this kind that "fairy rings," as they are called, are generally made in meadows. You have no doubt often noticed them in fields, and they are caused by the steady growth from the centre of a fungus family party. In the centre the original father and mother soon die away, having exhausted the soil, but the separate tips of what in them takes the place of roots go on branching towards the circumference, and the ring is formed with the bare patch in the centre. If the fungus be one that appears aboveground one may see standing up a complete ring of little posts, looking like a Stonehenge on a small scale. As a change in the character of the soil may check the growth of the ring, the resemblance is all the closer, for both the fungus and the temple look a little irregular and dilapidated.

Even in flowering plants the same ring development may sometimes be seen, for if a bunch of "Horse-mint," which you may find in any river ditch, be planted in a garden you will see it spread in just the same way, leaving its bare patch in the centre, and forming a widening ring of a growing number of individuals. It looks untidy, however, and the careful gardener will rescue the runaway shoots, as he calls them, and bring them home again to the centre.

The Frog-bit, a water-plant with leaves like a small water-lily, and a pretty, delicate, white flower, has practically given up making seeds, or at least very rarely succeeds in making any that will grow. From the base

of the leaves the plant sends out a long shoot with a leaf-bud at the end. This forms fresh roots of its own, the shoot decays, and the new plant sends out fresh shoots, until the whole colony may entirely cover a pond. In the autumn it makes fresh leaf-buds, but these do not expand at once. They are loaded with starch grains and so on,



THE FROG-BIT

and drop to the bottom of the ditch or pond. During the winter they lie quietly in the mud, but with the return of spring the cells expand and fill with air, and they float to the top to start work once more.

The common Lesser Celandine works in both ways for the future. The bright, yellow spring flower, with its glossy dark green leaves, you know well, but perhaps you have not noticed the leaf-buds that form at the base of the leaves in autumn. When the old leaves wither

they fall off, and are then carried along ditches by the autumn rains to found fresh generations.

A very pretty sight is seen on a common greenhouse fern, where the young plant is to be found upon the fronds, a complete miniature of its parent, with its own little fronds unfolded. After a time these too drop off into the soil beneath. A similar arrangement may be found in one of the houseleeks, the fat-leaved rosettes of which you must have often seen on the roofs of old houses. From the base of one of these leaves will come a fine thread, and at its end a round ball of leaves, which continues to grow until the filament snaps and the ball rolls off in the wind.

Seaweeds are spread very largely in this way. A storm comes on, and great shreds are torn away from the masses that cling to rocks, and the current carries them off to fresh positions. A scrap is caught on a rock, and, being of low organisation, is able to go on comfortably in its mutilated condition until it can renew its lost parts.

By using this principle of "vegetative reproduction" gardeners grow plants from cuttings, taking just one part of the plant, putting it in the ground, and allowing it to build up the other parts for itself. With Begonias one leaf is actually sufficient! This marks a great difference between the highest plants and the highest animals. You might feed a cat's leg with the most suitable food for a very long time before you could grow a new cat, and even if you had the rest of the cat the best nursing in the world would never enable it to grow a new leg. But almost any large part of a plant, if carefully treated, will reproduce the whole. All the various ways of growing plants from cuttings or by grafts depend upon this

principle, and there seems scarcely any limit to its application, although one is rather startled by Virgil's remark in the *Georgics* that some kinds of fruit trees are best grown from "four-cleft stakes or poles of sharpened wood." But perhaps the poet's exigencies of metre prevented the clearer explanation one would have liked.

The artificial interference of mankind with the distribution of plants is too wide a subject to enter on here, but one may note that it has had very great effect. There is an American pondweed called *Anacharis*, which in the seventies was brought over to England, and for some years drove all those responsible for the state of canals and slow-running rivers almost to despair. It spread at a tremendous pace, and despised all efforts to keep it down. Happily it was a plant of the advanced kind which requires two individuals to make a fertile seed, and only one had come over, but by means of the offshoot method it choked up canal after canal. After some years, partly owing to more energetic weeding of the rivers, and partly, perhaps, because it had exhausted the kind of food which it liked best, it was got under, and order reigned again in Warsaw.

This American invasion was bad enough, but English plants have succeeded in making themselves unpopular in other countries. Someone introduced watercress into New Zealand as a table dish, but the watercress refused to retain its humble form out there and has grown into a large and vigorous water-bush, stopping up streams and getting in the way generally.

In Australia a Scotch farmer planted a few thistles in his garden to remind him of home, but unfortunately they refused to stop in the garden, and they went forth and occupied the earth promptly, much to the disgust of

LING.

Face page 38.

the good farmer's neighbours, who considered that local patriotism might perhaps be carried a little too far.

This vegetative reproduction has, however, serious disadvantages when compared with competition by means of seeds and spores. The disadvantages are three: it cannot compete in numbers as a rule; the complete plants are not so hardy as seeds; and they are never likely to travel so far, unless, like the seaweeds or the pondweeds, they have got currents of water to help them.

As to the numbers, the figures given at the beginning of the chapter should satisfy you on that point. The hardiness of the spores and seeds deserves a word or two. Wrapped up as they generally are in a coat, or husk, they are not so much troubled by changes of temperature. The spores of funguses, for instance, ignore a degree of heat that would kill their parents at once, and the breath of frost that would devastate a wheat field would have no effect whatever on the unsprouted children. Some striking experiments in the same direction were tried by Professor Dewar, who tested the effect of extremes of cold upon such common seeds as peas, cucumber, and vegetable marrow. He immersed them for six hours in liquid hydrogen. Now hydrogen is an extremely volatile gas, and does not liquefy until it has been brought to a temperature two or three hundred degrees below the freezing point of water. A pea or cucumber plant, put into a block of ice, would speedily die, but these seeds, though in a far colder place, came out at the end of six hours as bright and clean as when they went in, and actually all of them, when put in the earth, grew up into plants! Seeds have also the capacity to lie dormant for a considerable time, starting into active life only when they find themselves in a suitable position. Actual ex-

periments have proved that seeds can live for thirty years, and everyone has heard stories of grain found in the Egyptian pyramids and sprouting after some thousands of years. There is a little difficulty about these stories, for the details of the experiments are hard to get, and the doubt always remains as to whether the corn may not have been blown in by the wind and recently deposited. However, the fact of the dormant life persisting for at least thirty years is fairly proved, and that is itself sufficiently wonderful.

An experiment which you may try yourselves is to plant in good soil the foreign seeds which are taken from imported wheat, for instance, from India. You will be quite astonished at the proportion that survive the voyage and the sudden change of climate, and start on business after, perhaps, a whole year's inactivity.

Upon this vitality depends the third great advantage of the seed method, and that is the distance to which a plant may spread its race. Moreover, there is this to be considered, that a plant, by sending its seeds to some distance, can get rid of their competition with itself, for the food there may be in the immediate neighbourhood of its roots. When, in later chapters, we go through the chief types of the plant world, we shall meet with various devices for spreading the seed, but we may now glance at some of them under the heads of the agencies employed.

Many plants devote themselves to putting out their family in good places by means of an explosive seed-vessel. The "fruits," that is to say, the seed-vessels, grow dry and brittle. A little touch, say a drop of rain, or the rustling of the wind, makes a small rent, and the case flies all to pieces like a Prince Rupert's Drop, jerking the seeds out far and wide. One of the best illustrations of

this mechanism is given by a plant which you may often see in a garden, the Egyptian Balsam. When the seed-vessels are ripe, and just touched with a finger, the strain of the elastic tissue within becomes too great, the sides fly out like the ribs of a collapsed umbrella, and the seeds are shot vigorously all about the garden, with the result of Egyptian balsams everywhere—even where not wanted—next summer. A smaller plant exhibits the same performance, the Brown Sorrel, and is equally rapid in covering all the available space. It has brown leaves, divided into three like clover, yellow flowers, and long, spiky seed-vessels. Brush your hand over one of these, and you will hear a furious spitting and see little mahogany-coloured seeds flying in all directions. This does not fly open like the balsam, but is more like a close-folded umbrella, where the silk suddenly splits along all the folds.

EGYPTIAN BALSAM SEED-VESSELS

If, again, you go on a hot afternoon near a bed of golden furze, you may hear the pods popping away with almost military fervour. As to the distance, such plants as we have in England are content with a yard or two at best, but there is a tropical plant, called *Bauhinia*, which has been known to fling its seeds eighteen or twenty yards, with a really effective explosion. It is obvious, too, that if an animal sets the machinery in motion, the seeds may stick in its fur, or possibly in its clothes, and thus manage quite a long journey.

Akin to these are the creeping and hopping seeds, examples of which may be found among the grasses.

Here the seed is provided with teeth, which are all set at a particular angle. This angle prevents the fruit from moving except in one particular direction, but the part which has no teeth is very subject to the influence of damp. It alters its shape according to the amount of moisture in the air, and as it changes shifts the seed from side to side. The teeth ensure that the plant shall only move in one direction, and so it slowly travels forward.

Some plants depend upon rain for the dispersal of their families, and the "Rose of Jericho," which was very famous in the time of the Crusades, has an elaborate arrangement with a view to this. When the seeds are ready to go, if the weather remains dry, all the branches of the plant curl over the seed-vessel, and wait there till the rains begins. Then they open, for the seeds have now a chance of being nicely planted by the rain. The showers come on, the seeds are washed out and carried along to some convenient crack. The sea sometimes performs a similar office, but there are no land-plants which seem specially to lay themselves out for its operations. Still, floating seeds like the cocoanut have been known to spread in this way from one South Sea island to another.

The commonest method depends upon the wind, and on the barren steppes of Asia, where suitable soil is rare and takes much finding, some plants of the parsley kind make elaborate arrangements for travel. The seed-vessels are very large and very light—as large as a hazel-nut, and so light that they cannot be felt when laid on the hand. The winds carry these rolling along until they meet with damper soil, on which they remain. Sometimes the whole plant breaks away from the roots

in the autumn, and goes travelling. If it meets with others the branches become entangled, and the wind continues sweeping them vigorously along until balls may be seen careering over the sand as large as a cartload of hay, ready to found a most varied colony if the wind will only take them to water, and not leave them to dry up altogether and die upon the sand.

LIME SEED. ASH SEED. DANDELION SEED.

You must have noticed some of the sailing arrangements on common seeds. Amongst the trees we have the winged fruit of the Elm, the pretty parachute of the Lime, and the boomerang blades of the Ash. Most of us have often started the seeds of the Dandelion, with their white sails spread, to hurry over the fields, and

have seen the thistledown travelling along to worry some farmer's heart. The beautiful white tassels of the Wild Clematis, or Old Man's Beard, are developed to carry the seed floating in the air.

Animals and birds, in their turn, have to play a large part in distributing seeds; and that is only fair, for, as we saw, it is on plants that they depend wholly for their own living. The birds may be trying in the way of devouring fruits, but then in return they often drop the seeds a long way off, and so do for the plant what it could not do for itself. Waterbirds, again, when floating in a pond, get seeds in their feathers or on their legs, and then carry them away to other ponds. Insects, such as ants, carry off seed-vessels to their nests, and do not eat the vital parts, and a squirrel's forgotten hoard may introduce a new visitor to a wood.

Animals are the great agents, for they carry off great numbers of seeds, and flowers make preparation to use them by arming their young family with barbs and hooks. You probably know a climbing, straggling plant that grows in hedgerows, which is called by various names, such as Stickweed, Goosegrass, and Cleavers, and bears little round seed-vessels about one-eighth of an inch in diameter and all covered with hooks, which you can feel and see without the aid of any magnifying-glass. These cling vigorously to your clothes, and you may carry them miles before you fling them into a new ditch. The burrs of the Common Burdock cling yet more closely, and it requires some real exertion to pull them off one's clothes, so you may imagine how far they may travel when fastened safely into the wool of a sheep's back, or in amongst the hairs of cattle. Some of these prickly seeds are really dangerous, for they have sharp spines,

which may stick in a sheep's foot and give him much pain before he is able to get rid of it. On the other hand, the seed may consider that the sheep ate its mother just before, and that it is only making matters even. The pattern of one of these seeds, by-the-by, was adopted at one time for an implement of war, and an iron model of the *tribulus* seed was often laid down in order to maim the feet of cavalry horses. You will remember that Robert Bruce's use of this somewhat unsportsman-like device was one of our various excuses for being so badly beaten at Bannockburn.

CHAPTER VI.

SEAWEEDS AND PONDWEEDS (ALGÆ)

First of all, I have to explain that the title of this chapter is rather misleading, for, in the first place, the great *algæ* class includes certain plants that live neither in seas nor ponds, but on snow; and in the second, there are a great many plants in the ponds which are not algæ at all, but most respectable and high-class flowering plants, such as the Water-lilies. At the same time, the seaweeds are the typical group in the class, and the green microscopic scum which you may often see on a pond is almost entirely composed of members of our present class. You will remember from Chapter I. that the algæ include all the plants which can boast of the green chlorophyll corpuscles, but are built up of nothing but cells, very often of only one cell. They possess neither true roots nor true leaves, but in some of the highest examples we get very near to leaves, and some of the large seaweeds cast up on the shore seem to have roots. These, however, are really nothing but anchors to attach the plant to rock or ship's keel, and have no share in the true function of a root, to suck up nourishment.

Everywhere in the world one may find representatives of the algæ—on the Arctic snow, in hot springs whose

water nearly reaches the boiling point, in the depths of the sea and on the tops of the mountains, on hard gravel paths and in any wayside puddle. Sometimes they live quietly within other plants, as in the bog moss, and one particular species has taken for its home the feet of the three-toed Sloth!

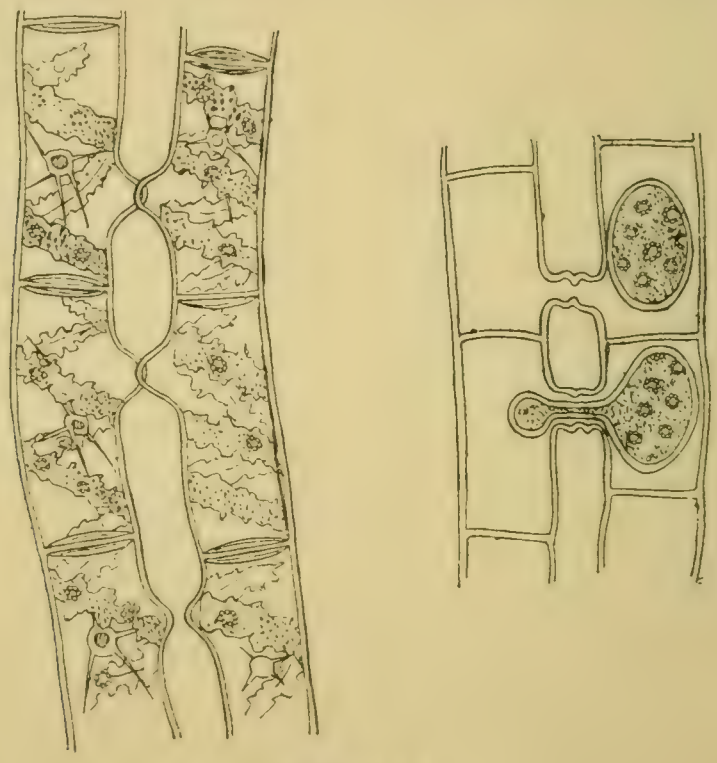
Just in the same fashion they vary in size. Thousands of species are quite microscopic, while others in tropical seas are of the thickness of a man's thigh, or perhaps cover the surface in a vast mass, which may delay the progress of a ship. Such a case is shown in the Atlantic in the "Sea of Sargasso," where for miles and miles the water seems but a tangled mass of weed.

As yet the classification and arrangement of all these countless individuals are incomplete and uncertain, but a general idea of the progress of development up to the mosses can be obtained by grouping them according to the manner in which they produce fresh individuals.

In the lowest group come all those which, so far as we know, only form fresh plants by splitting themselves into two or more. Most of these consist simply of a single cell, and as a rule they live in large colonies, forming green patches on submerged stones, or sometimes on trunks of trees. Their enormous number may make them important, for on one occasion (see Kerner and Oliver, II., 621) "a form, probably referable to this group, made its appearance off the Adriatic coasts in such numbers as seriously to interfere with the fishing industry. A commission was appointed to investigate the matter, but in six weeks it vanished as suddenly as it had appeared." To tell the truth, as yet we do not know very much of the history of these plants.

The second group includes those that effect repro-

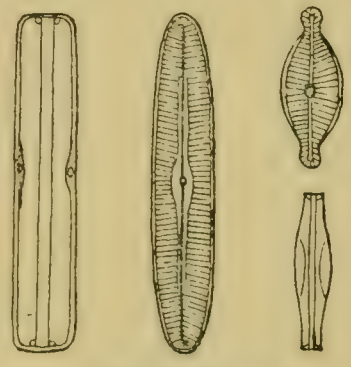
duction by *conjugation*, a process which may be thus described. Two cells, apparently similar to all the other cells in the plant, separated from one another, show a swelling on the near sides of their cell-walls. The swellings grow until they meet and then fuse, forming a tube from one cell to the other. The protoplasm flows together into one or other and forms what is called a *zygospore*. This slips away from the plant and starts a fresh existence.



SPIROGYRA.

A good example of this method is seen in "*Spirogyra*" (it has no English name), a plant with long threads of cells, which unite with one another until two threads look like a long ladder, the tubes forming the rungs. A very well-known group in this division is formed by the diatoms (a word meaning "cut through"). They get their name from the fact that their cell-walls consist of two halves, fitting closely to one another like the halves of a pill box. These are distributed in enormous numbers

in all waters, fresh and salt, but their chief interest lies in the fact that the cell-wall is always encrusted with silica, the mineral which is found almost pure in flint. In the diatoms this takes most beautiful symmetrical shapes, and this shell remains when the plant is dead, and sinks to the bottom of the water. Some idea of the enormous number that exist in the sea will be gained when you realise that though each cell is microscopic, fossil beds have been discovered in various parts of the world in which the diatoms lie to the depth of several feet. The most famous of these beds of "infusorial earth" is in America, near Richmond, the capital of the Southern States during the great war of North against South. This extends for many miles, and is on the average forty feet deep. Now the number of shells in two cubic feet has been estimated at twelve billion, so one can hardly conceive the number in a bed such as this.

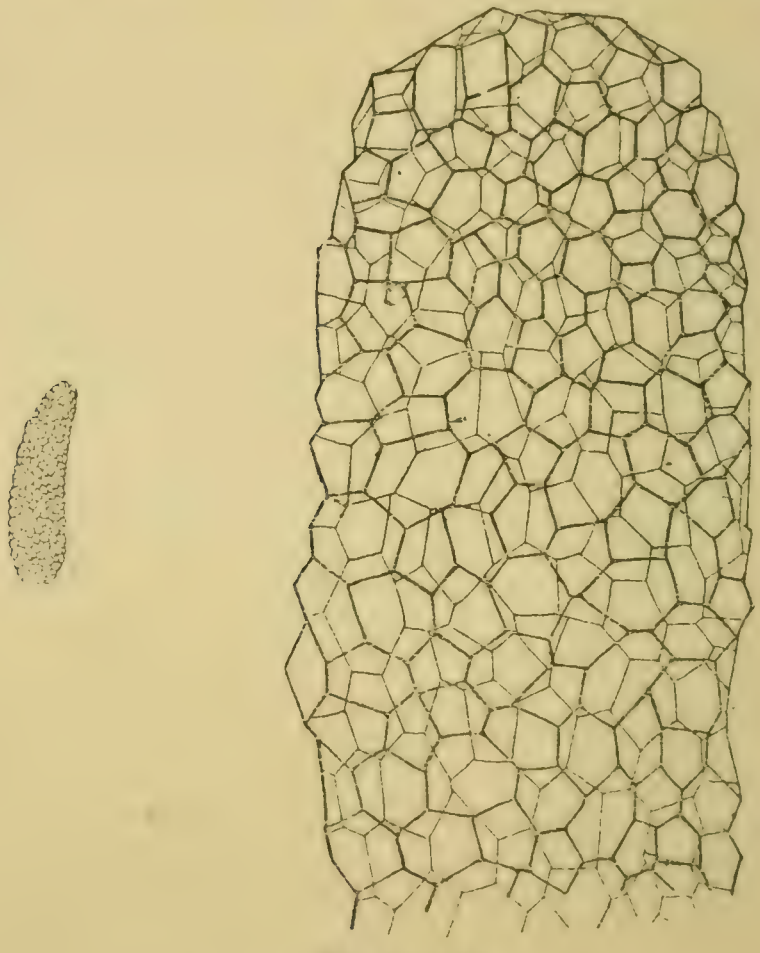


DIATOMS.

Another example of the group is the tiny *alga*, which gives rise to the appearance known as "Red Snow." This was first noticed in Savoy by De Saussure, in 1760, who failed altogether to account for it; but a much more splendid exhibition was seen in Greenland by Captain J. Ross, on the so-called Crimson Cliffs. Patient study with the microscope revealed the true nature of this extraordinary phenomenon. The whole surface of the snow is covered with the cells of one of the algæ, the cells of which are permeated with the brilliant red. One asks how it can live in such a position, and the answer is that it dissolves the snow for water, and the rest of its nourishment it obtains from the dust blown by the wind

over the wilderness of snow. In Switzerland, one may note, the chief article of diet is formed by the decaying pollen grains which are blown along the snow from the great pine forests of the country.

A microscopic colony of great beauty is the water-net, of which the illustration will give a better idea than



WATER-NET.
Natural size and top enlarged.

much verbal description. The cells of the colony "conjugate," and a new water-net is formed within, escaping by rupturing the cell-wall.

The third class shows a marked development, for division of labour has begun. Special cells are set aside for reproduction, corresponding to the flowers in higher plants, and of these cells there are now two kinds, which

may be considered as the father and mother respectively of the young plants.

To this belong all the brown Seaweeds. The green Seaweeds, such as the Sea-lettuce, belong to the second class, the "conjugates." A good example of the brown seaweeds is the well-known Bladder-wracks, which one may find anywhere on the beach, conspicuous by its inflated cells filled with air, which serve to keep it afloat, and its flat, much-branching structure.

BLADDER-WRACK.

In certain parts of the plant there are pits, mother-pits and father-pits. In the one little balls or eggs of protoplasm are developed, and, at the proper stage, they are allowed to pass out of the pit. Meanwhile in the father-pit pieces of protoplasm of different shape have been produced, and these also pass out into the water and coalesce with the eggs. The first effect of the combination is that the ball of protoplasm, which was formerly naked, is able to build itself a cell-wall, and after a rest of some time, it becomes a full-grown Bladder-wrack with pits of its own. This is certainly a more elaborate method than mere splitting, or even the coalescence of two similar cells, and marks a considerable step forward.

In a very common fresh-water alga, called Vaucheria, we find a somewhat similar arrangement. Each plant consists of a single branching tubular cell as a rule, but

when a family is required, a transverse wall is run up across one end of the tube, making a nursery, so to speak. On the outside of the tube are developed two separate organs, one thin and curved like a horn, and the other round. In the latter masses of protoplasm are separated off, but they do not leave the mother-cell until other pieces have been expelled from the horn, which descend upon them and give them the desired ability to construct a cell-wall for themselves.

As a last example we may take almost the highest of the algæ, the Stoneworts. These appear to have advanced so far as to have leaves, for they have whorls of leaf-like appendages at the joints of the stem, but these are not sufficiently different in structure to count as true leaves, though we are approaching very near. The Stoneworts may be found in almost any gently-moving water, and especially on the Norfolk Broads, where they form a dense carpet upon the muddy bottom. So numerous are they that as they rot they steadily make the water shallower and shallower, for their decaying plants contain a great deal of lime which they have drawn from the water, and it all tends to silt up the channel. This process can be seen at work rapidly on such broads as Hickling and Ranworth.

Besides their claims to respect by reason of their attempt at leaves, the Stoneworts are distinctly high-class in their fructification. On the leaf-like appendages are formed two kinds of organs, corresponding to those of Vaucheria and the Bladder-wrack. The father in this case is a spherical orange body, contained by eight plates which lock into one another and enclose, springing from their inner side, long hairs. These hairs consist of strings of cells, in each of which is a small piece of

travelling protoplasm. The mother-cell, on the other hand, which is close by upon the same branch, contains the "eggs," enclosed by five spiral tubes, which run over the top of the nest, as one may call it, and form a cap. After a time the orange-coloured father breaks up, and the morsels of travelling protoplasm escape from the hair-cells. They travel about in the water until they find a mother-cell. They force their way down between the twisted tubes and fertilise the waiting plant eggs.

In the next chapter we shall see how there are parallel groups to these three amongst the funguses, and from them we shall go to the mosses and the ferns.

CHAPTER VII.

FUNGUSES

You may perhaps feel at first that this chapter might be omitted from a book on Botany, or at least that it must be very brief. Mushrooms and truffles perhaps deserve to be included, for they are good to eat, but surely very few others. Even from the eating point of view, however, there are several other kinds or species which are worth knowing, though I do not advise careless experiment, for some are most deadly poisons. I have tried thin slices of the larger puff-balls fried in butter, and if anyone has a taste for fried boot-soles, this dish should meet their views exactly. But the edible aspect is of very small importance when compared with other considerations. Our own bodily health and disease are most intimately connected with this group of the vegetable kingdom. Its members bring the most terrible blights and pestilences, and may leave lasting effects upon history. You may remember the Black Death in England in the reign of Edward III., which carried off one-third of the population, gave one of the motives for Wat Tyler's rebellion, weakened us in our wars with France, and permanently altered the conditions of labour. Well, all this was caused by the invasion of one kind of fungus.

On the other hand, the whole of recent Irish history

has been affected by the terrible potato famines of fifty years ago, and by the resulting emigration. We ourselves felt the effect of the invasion, for it hastened the Repeal of the Corn Laws in the United Kingdom. It was another little microscopic fungus that brought about all this.

But do not think that the influence is wholly evil and violent. All the fermented drinks, beer, wine, and ginger-beer, depend for their formation on a third fungus, and others are busy everywhere hastening decay, and ridding the world of matter in a dangerous form and getting it ready for use again.

Still, on the whole, the funguses are not popular. Their evil effects are conspicuous. Their good deeds are hidden away. Also they are generally rather grotesque in appearance, and they almost always contrive to have a smell that is most unpleasant to us, though hugely attractive to flies.

Though we are taking them after the algæ, do not think that they rank any higher in the Vegetable Kingdom. They may be considered as parallel groups, forming together the lowest grades of plants. If anything they are a little lower, for their great distinction from the algæ lies in the fact that they do not possess the valuable machinery of chlorophyll. The result is that they can make no starch grains, nor can they break up the carbonic acid in the air. As they cannot build up their required food from its raw material, they are obliged to get it ready made. There are two methods which they may adopt, (1) to quarter themselves on other living things, sucking up their prepared juices, and (2) to feed on dead and decaying remains of living things, or on such products of living plants and animals as fruit made into jam, or milk.

The first class comprises most of the mischievous funguses, and they are all called "parasites," a word which means "one who sits at table with another," and of course feeds at his host's expense. The second class, many of whose members are of great value to us, includes the yeast plant, the mushroom, and others.

Excluding the plants of a single cell, which can only be distinguished from the small algæ by the absence of chlorophyll, we may say that the typical fungus plant consists of long thread-like tubes, composed of a single row of cells, which run all about the host which it has adopted, whether that host be decaying leaf-mould, manure, jam, a caterpillar, a fly, or a living plant. These tubes, or filaments, are called *hyphæ*, and sometimes they weave a web over the surface, and sometimes bore their way through and through the body nourishing them. These hyphæ keep on branching and intertwining until they may form a closely-matted mass, such as you may see in a brick of the so-called "mushroom spawn," which is really the plant itself. "But," you will say, "the mushrooms and the toadstools, the great funguses one may see on trees, do not look like branching tubes at all." This is true, but the great point to remember is that the ordinary mushroom you see in the fields is not the main body of the plant. That is buried beneath the soil, and what you gather is merely the fruit, which comes up in this way with the intention of scattering its spores in the wind. Just in the same way, the hyphæ of the tree fungus are driving their way like ship worms through the timber, and though you knocked off what you could see, you would only destroy the year's fruit and not the plant itself.

There is, however, one group of organisms generally

included in the funguses which show none of these tubes nor even cells. This group is called the *Myxomycetes*, and I am sorry to say it has not yet obtained an English name for you to remember. A long fight has been kept up as to whether these should be regarded as the very lowest grade of animals or as the very lowest grade of plants; for, widely as a cow may differ from a cabbage, when one goes to the bottom of the animal and plant ladders, the line between the two is very difficult indeed to draw. Most scientific people now are inclined to place the group among the plants, but they are of a very extraordinary type. Though 450 kinds have already been discovered, it is unnecessary to go into details, and we may remain content with a general description. The most extraordinary fact about them is that they have no cell-wall for the greater part of their life, but are merely masses of naked protoplasm. They are highly social in their habits, and form large colonies, amalgamating into a sort of layer of jelly, sometimes of several square inches. This layer slowly flows, as it were, over the surface of its food, which may be the bark of a tree, a piece of spent tan, or rotting wood, and picks up what food it requires as it goes along. After a time, when the colony feels that it has to make a new family, the protoplasm stops flowing round, and separates into stationary patches. These patches collect further into balls, and then form a kind of cell-wall, not, so far as we can tell, of the ordinary cellulose material, but of its own protoplasm jelly. When the wall is made, the ball rests for a time, whilst various spores are formed within it, each now provided with a coat. When fully ripe, the ball splits, and out pour the spores, which soon slip from their coats and begin the foundation of other crawling colonies.

Leaving these indefinite creatures, we come to the great single-celled family, which includes the Bacteria. This group has only recently attracted attention, so lately that the ninth edition of the *Encyclopædia Britannica* does not give an article on Bacteriology; but of late years a vast amount of attention has been devoted to them, for it is held that some of them are the cause of diseases, amongst them cholera, plague, and typhus fever. But it would be most unfair to their character to imagine that all of them are evil. Vinegar is formed by the active exertion of one kind of bacillus, and there are others known as the sulphur and iron Bacteria, which are busily employed in making compounds of sulphur and of iron for the roots of higher plants to take up.

Then there is a second group which appears to be quite harmless. There are certain kinds always to be found in our own mouths and noses, others inside the body in the alimentary canal, in which they seem to do no damage whatever, and possibly may give us active assistance, though it has not yet been discovered in exactly what way.

Then comes the third group, those that are known to produce disease. These are all single-celled and of various shapes. The fungus that produces diphtheria is round; that of cholera is a bent rod, called from its shape the "comma" bacillus. The plague bacillus is a straight rod, and another may be spiral. All multiply by simply dividing the cells, splitting again and again at the expense of the nourishment in the host. One new cell will in twenty minutes be ready to split again, and produce another; and as each goes on splitting you can see at what a fearful pace they may multiply in a man's blood, if the condition happens to be exactly

favourable. Exactly what the favourable conditions are is not known, nor why, with the people exposed to the same infection, one should be seized on by the bacteria as a suitable feeding-ground and the other go scot-free; but the object of vaccination and similar operations is to put some substance into the blood which will make it unsuitable for the invading fungus, and never let it multiply. Even when it has taken a hold of the body substances may be injected into the blood which are thought to be fatal to the growth of the guest, as is often done now when the diphtheria fungus has taken possession of a patient.

When the bacteria have absorbed all the nourishment that suits them they may either die or may form spores from their cells. These spores, forming bacteria, are very dangerous, for they take a great deal of killing, and can wait for a long time without food in this condition, and are very easily blown about to spread infection.

Very little higher in the scale are the yeast plants, which secure the rising of bread and the fermenting of wine and beer. The actual effect of their growth is to split up the sugar in their hosts into two substances, alcohol and carbonic acid. When the yeast plant is well kneaded up with flour and water the bubbles of gas are caught in the tough dough, and the whole mass rises. Then, in the baking, the alcohol evaporates, and the bubbles of carbonic acid swell up with the heat, and make the loaf fit to eat. When beer is made, on the other hand, the carbonic acid is mostly allowed to escape, and the alcohol to accumulate until the required strength is reached. Ginger-beer is made in much the same way, except that the yeast plant is only allowed to grow until it has made a very small amount of alcohol, and the

carbonic acid is kept as far as possible in order to make the liquor frothy. It does occasionally happen that the yeast plant goes on working longer than it ought, steadily making alcohol, and some bottled ginger-beer is a very doubtful temperance drink. The yeast plant itself is very simple in structure; it consists either of a single cell, or a branching chain of loosely-connected cells, which easily become detached from one another. Reproduction is very simple, and is produced by "budding," that is to say, starting with our single cell, the first change is a bulge in the side of the oval wall. This bulge increases, some of the protoplasm flowing into it, and after a time the opening is walled off, and the new cell begins to bud, sometimes breaking away from its parent, and sometimes preserving the bond of union, though certainly enjoying entire home rule. The various yeast plants, some sixty in number, all work in much the same way, though according to the medium chosen, grape juice or barm and so on, they produce slightly different flavours.

You will remember that the great test of the progress of a plant up the scale of vegetable society is the question, "How far has it adopted division of labour, especially in the matter of reproduction?" Such fungi as we have hitherto described are very simple, but when we come to higher forms, such as moulds, toadstools, and so on, we find there are traces of advance. In the first place, special structures are set aside for the purposes of a new family; and, in the second, we sometimes find a double set of machines, differing from one another, and corresponding to the stamens and pistils of flowering plants, or the father and mother pits of algæ. But the curious thing is that we find both methods at work upon

the same plant, and very often there is evidence which goes to show that the double machinery has once been more effective, and that the plant has fallen back upon the simpler and less advanced method. Sometimes the double machinery seems to have forgotten how to work, and there are only ineffective traces of it; this is what is meant by the "degradation" of plants. It would appear that many generations back they had learned to use the double machinery, but now they have forgotten it, and fallen back in the scale.

Generally speaking, the single set of cells is throughout the fungi the most important method. The Common Mould, for instance, occasionally forms fruit by "conjugation" of two separate hyphæ, but usually simply throws up a long tube with a comparatively large knob at the end, in which spores are formed direct. In an allied group of aquatic Fungi, called *Saprolegniaceæ*, the double machinery is present, but so far as observers have been able to make out it refuses to work. This group contains one member which attracts a good deal of attention, for it causes the well-known salmon disease, of which so many complaints are heard. It grows upon the salmon's scales, and in time may cause the death of its host, and, which is worse, may spread abroad to the other fish in the river by the spores which it produces freely enough by its single set of machinery.

The Potato disease I have already mentioned, but its effects in Ireland were so tremendous that it requires a fuller description. The hyphæ, or tubes, run all about the leaf of the plant, turning it black, and causing its death. Meanwhile, certain tubes run up through the pores of the leaf and bear their fruit outside, the wind distributing it all about the field. Each leaf and plant

may thus become affected, and, which is even worse, it may sink to the ground and make a home in the potato tuber beneath. If these are used for seed in the next year the disease is certain to reappear and take an unshakeable hold upon the plant.

On the other hand, while some of the funguses are thus destroying what is useful to mankind, others are trying to keep down some of his pests. Potatoes may be killed by the fungus, but cabbages are being gnawed through by the caterpillar of the Cabbage White Butterfly, so, as some compensation, another fungus makes an onslaught on the caterpillar and completely fills it with its branching tubes. The common House Fly, after annoying everyone during the summer, often in the autumn pays the penalty to a third small fungus, which completely envelops the fly in a halo of its fruits, as you may see for yourselves if you examine dead flies about that time, especially those you may find on the window-panes, where they go for rest, and are fastened down by the sticky cords of the fungus.

The Mildews, Smuts, and Rusts we must leave, for our space is not sufficient to deal with all these pests of the farmer, but with them, as with most other fungi, there is one thing worth remembering. What you see of them, either the black smut in the wheat ear, the mildew on an apple tree, or what not, is the fructification only of the plant. The mischief is being done, and all these fruits are being produced, by the thread-like tubes running all in and out among the cells and tissues of the host, and sucking out its life-blood. Many curious excrescences on plants are the effect of a fungus invasion. You may know the "Robin's Pincushion" on wild roses. This is the result of a fungus invasion, which has stimulated the

particular part attached to unnatural growth, and of the same kind, on a larger scale, are those bunches of close-set twigs coming in an unnatural way from the branches of the birch, and looking for a moment like the wreck of a jay's nest. These, by-the-by, were a great puzzle to our forefathers, who solved the difficulty by declaring them to be "witches' brooms." So they may be, but the witch in this case is simply a boring and twining mass of fungus tubes. Still the treatment once given to so-called witches is a good example to follow, for branches so infected should be at once cut off and burned, fungus and all, to encourage the others.

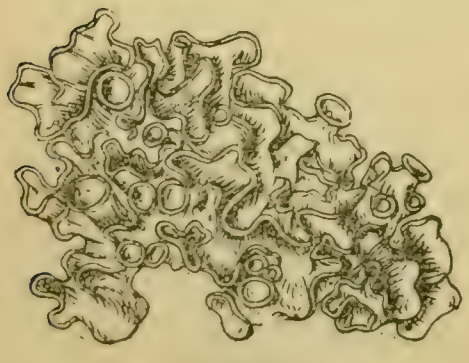
We now come to the mushroom and toadstool group, which in many ways is highly developed, but which shows no sign of the double machinery for reproduction. From their advanced stage in other things, one would imagine that they had once possessed them, but that capacity for their use had been lost by neglect.

The general type of plant consists of the usual branching *mycelium*, but the fructification is in the shape of a stalked cap, on the under side of which are many flat plates known as "gills." On these the spores are formed, quietly dropping, as a rule, to the ground when ripe. The common puff-ball varies somewhat, for the spores are kept in a tough ball until they and their holders have passed through three stages. First, they are tough and fairly dry like a mushroom; then they become squashy and slimy; and then they take the form of dry dust like snuff. The top opens, and the wind carries the spores all over the field.

PUFF-BALL.

The Stinkhorn fungus—a cheerful name—one may occasionally find in damp woods in England, and it is worth examination. One can generally track it down by the strong smell, which is sometimes perceptible ten yards away. The fruit part consists of a thick fleshy stalk, thicker than the thumb, and about six inches high, with a swelled head. When ripe this head becomes slimy, and all the bluebottles in the neighbourhood are attracted by the beautiful carrion flavour. They settle on the top, and get some of the slime upon themselves. Of course there are numbers of spores in the slime, and the stinkhorn successfully disposes of its family, with the cheerful conviction that in all probability the bluebottle, being filthy in its habits, will leave the young emigrants near some other carrion or rotting matter, where they will feel themselves quite at home.

I have left to the end of the chapters on algæ and fungi the description of what is, perhaps, the most extraordinary vegetable group in the world, namely, the Lichens. For many years they were a puzzle to botanists, in fact, from the time when attention began to be paid to such lowly forms, but it is only in the last thirty years that their true nature has been established by the researches of a botanist named Schwendenberg. To put it quite shortly, a lichen is not *a* plant at all; it is a family party of two quite different plants. The whole group, members of which you may see everywhere, encrusting walls, rocks, and trees, is composed of permutations and combinations of fungi and algæ, living and working in alliance. It has been found that the algal members are quite capable



LICHENS.

of living by themselves, and so is at least one of the fungal members, but the association has been formed for mutual benefit, reminding one of the joint colonies of prairie dogs and owls upon the North American prairies, though the lichens have nothing to correspond with the rattlesnake, which some have declared to be a third amiable partner there. Of course, one would be inclined at first to suggest that the fungus was merely a parasite, and just lived on the alga, but this is not the case, for the alga flourishes exceedingly, and is more prosperous than when alone. They live together for generations, and actually send out joint colonies. The arrangement seems to be that the fungus absorbs water and raw material for food, and hands them over to the chlorophyll factory of the algal cells, where they are made into suitable compounds for the digestion of both parties. The fungus is generally outside, and protects the alga from the cold and heat and so on, and does its share of the joint business quite fairly, in a very different style from its pestilent brethren that suck the life out of the Potato plant, for instance.

The same alga may go into partnership with several kinds of fungus, and it is generally quite the junior partner of the firm. The fungus being outside generally seems to have the decision as to the direction of growth and so forth.

As to reproduction, the fungus grows special spore-cells, and these are carried off by wind and rain, generally to look for a suitable alga, also blown about by wind or rain, with which they may join forces. Sometimes, however, algal cells are thrown off by the plant at the same time, in order that they may be sure of finding partners. The plant may depend chiefly on the first way I men-

tioned of spreading its race, that of vegetative reproduction. Part of the thin fungal threads, or hyphæ, roll themselves up into a ball of felt, as it were, with a few algal cells twined among the filaments. These appear first below the surface, but shortly push their way up above and come out on the top as buds. Their casing splits, and the swarm is carried away, on just the same principle as a swarm of bees from a hive.

Lichens are classified according to the families of the funguses which control them, and they are again subdivided according to the fashion of their growth. The three divisions are the encrusting Lichens (Crustaceous), the leaf-like Lichens (Foliose), and the branching Lichens (Fruticose).

The first are the commonest of all, and we see them clinging in patches and circles to rocks and walls and smooth trees, so closely that they cannot be torn away without injury, and slowly eating a way into the hard rock by their acid sap, and etching the outline of their shape. Each plant is insignificant enough, but by their number they often give a touch of colour which adds wonderful beauty to wild rock scenery, such as you may see even in England in the Lake District, in the Wastwater and Scafell region.

The leafy lichens, though still adhering to their homes, and spreading over them in ribbon-like strips, can be detached easily enough. Amongst them are the bright yellow lichens that you may see on rough bark, and the leafy green lichen that is to be found among mosses in damp parts of a wood.

But the most beautiful lichens by far are the branching group. The fantastic shapes give a grace to decaying wood and to the damp banks, which otherwise have too

much a flavour of death to be pleasant. The rotting twig is beautified by the grey pendants of the "Old Man's Beard," as it is sometimes called, and near by, perhaps, the mouldering earth may be adorned with the green branches and the crimson cups of the Cladonias.

In this group are included the litmus family, which is of the highest importance to chemists. From it is prepared litmus paper, which has the extraordinary power of changing colour in presence of certain chemical qualities. It may be either blue or red, but if you hold a blue paper over a fuming acid, *e.g.* hydrochloric acid, the slip will promptly turn red before your eyes. Then hold it over the opposite of an acid, an alkali, such as ammonia, and it will immediately go blue again. If you happened to have a red paper originally you would see the process reversed.

Other members of this group of some importance are the Iceland Moss, which is used for jellies, and the Reindeer Moss, upon which the reindeer in Norway live in the winter, using their broad, shovel horns to clear away the snow. Of course neither of these can be called a true moss, for they are not yet in the proud possession of differentiated stem and leaves. The highest algæ, as we saw, approached the stage, but could not fairly be said to have entered on it. We always have to remember that classes and groups shade into one another, and the best man in the second eleven is usually just about as good as the worst man in the first.

So we leave our algæ and fungi, and pass respectfully to the Mosses.

CHAPTER VIII.

THE MOSSES

We noticed, at the close of the algæ, that we had come to forms of plants which bore something very much like leaves, forms which were no longer content with mere ribbons, or masses of cells, nor with simple continuously branching tubes, and we now come to the group of plants which have fairly and beyond all doubt crossed the boundary, and are possessed of a perfectly definite stem and leaves. This is true, I say, of the group, but we must still remember what was said in Chapter I. about classification. Nature does not draw hard and fast lines between class and class, and the mosses have certain poor relations in the shape of the liverworts, some of which have either never learned to produce leaves, or else have degenerated and forgotten the way. Yet by their general fashion of growth, and above all by their way of reproducing the family, they are obviously so closely allied that we cannot separate them, and must regard them as boys whose general work entitles them to be in some particular form, but who in one particular subject of the form's work are hopelessly unable to keep up. With these exceptions we shall have little more to do. They are the fit subject for a more detailed work, but we must first grasp the general type before trying to comprehend the

eccentric individuals that worry us by hankering in some point or other after a higher or lower subdivision.

The great glory, then, of the mosses, as compared with the algæ and the fungi, is that we can clearly see their differentiated stem and leaves. Some, it is true, are so small that the different parts cannot be separated without a magnifying-glass, and in some the leaves are but small scales which require a good deal of searching for, but they can be found with a little trouble. Not only have they stem and leaves, but also they have something approaching to roots. The seaweeds sometimes seem to have roots, and one notices, after a storm, pebbles thrown up on the shore wrapped up in what look like the fingers of the base of some ribbon-bodied alga. But these growths are not true roots; they are merely anchors, and do not perform any function in the way of taking up nourishment for the plant. Now the mosses and liverworts do not send down bundles of tissue like the plants we know better, but on their under side are "root-hairs," such as those which cover the actual roots of ferns and flowering plants, and these are busy in taking up the water and mineral salts that are necessary for the plant.

On the other hand, the mosses are still cut off from the plants above them by the fact that they consist of cells only, and have not yet learned to combine the cells into vessels. The "bundles" of Chapter III. are not to be found in mosses or liverworts, but, and this is most important, we do find indications of various cells in the plant being modified for special work, and especially the cells in those parts of the plant where the bundles will appear when we reach the next group. You will remember, for instance, that the veins of the leaf are

formed by the extremity of the bundles, which mass together to form the main part of the stem or trunk, as it may be, of the plant. Well, in moss leaves we find the system beginning, for one can notice at once in most of them a "mid-rib," which is different from the general substance of the leaf. This is composed, not of vessels, but of a double or triple row of specially constructed cells, which do not seem to take part in the manufacturing duties of the leaf, but foreshadow the duties of the bundles by acting chiefly as conductors of the products of the other cells in the leaf. This mid-rib is often continued right into the stem, and we see that it is not a very long step for them to combine into the central mass we discussed in Chapter III. We also find that there is now quite a distinct skin, a layer of colourless or darkened cells, which contain no chlorophyll, and which have for their duties simply the protection of the working cells within from heat, cold, and other injuries that might retard their action. Up the centre of the stem there runs also, not a vessel, but the next thing to it, a column of specially elongated cells, whose walls are strengthened so as to give support to the plant, whilst at the same time they are good conductors of nourishment from part to part.

This is a general outline of the moss structure; and now we come to the question of their methods of performing a plant's great duty, the reproduction of its kind. There are the two methods, vegetative reproduction and reproduction by seeds or spores. (Of course flowering plants are the only plants that can produce seeds. The rest, ferns, mosses, funguses, etc., have to be content with spores.) Mosses employ the first method to a vast extent, and, being rather low in organisation,

RAGWORT.

Face page 70.

almost any part of the plant, if cut or torn away, can reproduce another plant with ease. Their stems run underground, throw up a new shoot, and wither away when it is established; small plants are formed on the moss plant itself, and drop off when fully fledged, and fragments carried off by rain or wind to suitable soils speedily establish themselves afresh.

The spore-reproduction, however, is a more complex business, and we now come to a fact in vegetable life which needs your careful attention. This fact is known as the "Alternation of Generations." Put quite briefly, and therefore with only rough accuracy, mosses don't have children at all like themselves, but only grandchildren! It is not the same transformation as that of a caterpillar into a butterfly, for the plant in one stage may go on for a long time producing plants in the next; but a nearer parallel, though not one to be followed too closely, would be if the children of horses were donkeys, and of donkeys, horses.

In one generation of mosses we find two kinds of organs for reproduction, which have to combine by some means or other; the details of the process we shall go through later. When they have combined, a new plant is produced, which commences to grow independently, though not breaking away entirely. Within this new plant, which does not look at all like its parent, spores are formed, without the assistance of any double set of cells, to an enormous number, and these are spread abroad to grow up into new plants, each with its double set of reproducing cells. The first plant, with its male and female organs, is known as the *sexual* generation; the second, which produces spores, as the *asexual* generation.

To bring this out rather more clearly, let us go through

the life history of a common moss plant, such as that which grows so commonly on walls, known at once by its long-stemmed red "fruit," as it is called, though this "fruit" is really a separate moss plant of the second generation. We begin with a minute single-celled spore, which we may imagine falls upon suitable damp soil, and begins to germinate. The first stage of its development is a branching system of thread-like tubes of cells, which form a close mat over the surface of the ground. At this stage the moss plant has just the appearance of one of the algæ which branch in the same manner over ponds or, as one may see them better still, over any glass vessel containing still water, such as that of a model aquarium. It was some time before this form was recognised as a form of the moss at all, and it was considered another kind of plant life altogether; but further observation brought to light the fact that, usually at the elbow of one of these branching threads, there appeared a leafy upward-growing bud. From this are developed branching stems, at the end of which, in due time, appear the organs of reproduction. Sometimes among the mosses both sexes are found side by side, but in the special example we are now studying, the shoots

YOUNG MOSS PLANT.

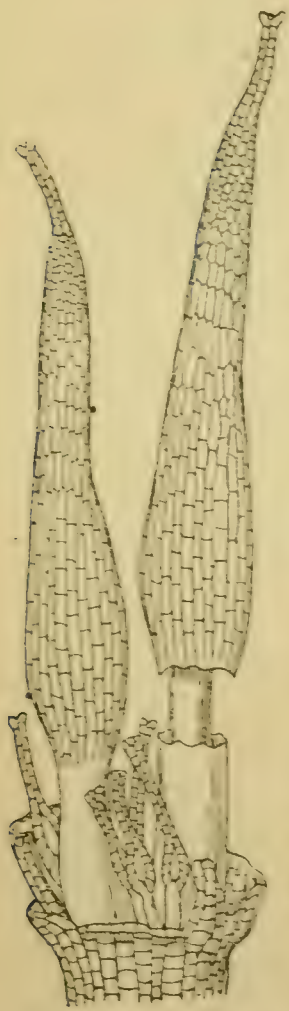
each confine themselves to the production of one sex only.

The male organs, as the "antheridia" may be shortly called, are, when fully grown, long bags, crowded with little cells. At the proper time, when each cell has obtained all the nourishment it will require to do its work properly, the bag splits, and the cells are squirted out, to go and fertilise the female organ. They can only travel about in water, so the moss plant always endeavours to collect moisture all over its leaves, to give them a chance of a voyage. In a very little time the cell-wall splits, and all the protoplasm escapes. The wonderful fact is that the contents have previously formed themselves into a definite shape, quite different from the ordinary jelly lining of the cell-wall. Under the microscope the contents appear like a very small snake, with two whip-like lashes to its tail. With these lashes it drives itself along through the moisture enveloping the plant, and goes in search of its duties.

"ANTHERIDIA."

Now we turn to the mother-cells of the future moss generation. Upon other shoots these "archegonia" have been developed, and they have a more complicated construction than the other organ. In shape they are like a very long-necked flask, such as those in which Italian wine is put on the table. One row of cells runs down the middle, and another row forms a coating all around it. At the swollen base the cells of the middle row expand, and there is formed what roughly corresponds to the seed-vessels of flowering plants. The cells of the centre row, when the mother-cell is ready to be fertilised, turn into mucilage, or jelly, and offer an easy passage for the snake-

like pieces of protoplasm that are wandering over the surface of the plant. It would seem that this jelly is not only easy to pierce, but actively attractive through some chemical secretion. Once having reached the top of the bottle, the visitors speedily bore their way down the neck, and reach the mother-cell. The two different forms of protoplasm now become one, and fertilisation is complete. The mucilage, its task done, dries up and disappears, and the new moss-fruit is ready to begin the life history of the second generation. For a little time it remains quiet, and the first sign of action is the building up of a long stalk, which carries it far above the old base at the tip of the branch. This stalk you must often have noticed, with the nodding red capsule at the end, and it is, so to speak, the trunk of the new tree. At the base of the stalk is a sort of foot, which plants the whole firmly in the original moss plant. The new generation still draws some nourishment from the mother, but by no means all. During growth, the green cells are working away to make carbon products, and all that they demand from their base is water and the mineral substances that can be got from the soil. The second generation, in fact, bears much the same relation to the first as the mistletoe to the apple or birch tree on which it has been planted.



"ARCHEGONIA"

Meanwhile growth proceeds fast. The outer skin of the flask, which was content to stretch for a while to meet the swelling of the contents, is at last forced to split, and the upper half is borne triumphantly aloft on

the case of spores, like a cap of liberty. In the centre of the now inflated flask there is, amongst all mosses, a mass of tissue which does not itself form spores, but has its use as a storehouse of nourishment. Between this central mass and the lining a vast number of spores is forming and fattening upon the friendly tissue. When the time comes, the lid at the top springs open, and the spores are flung out.

There is one interesting device on the part of many mosses which demands a moment's attention. It is highly advisable that the spores should go out when it rains, so as to give them a chance of settling with a little moisture. As a device to secure this, many mosses are equipped with teeth about the aperture through which the spores must pass, and these teeth are very sensitive to damp, spreading open when they feel moisture in the air, and closing back upon the spores when it is too dry for them to have a fair chance.

Such is the general life-history of a moss, of one, that is to say, which reproduces by spores. But do not forget that many mosses employ this method rather sparingly, and for the most part are content to spread in their own immediate neighbourhood by underground roots, or by the forming of young plants like themselves on their branches.

The Sphagnum, or Bog-moss, for instance, is chiefly spread in this "vegetative" way, and that it has been fairly successful is shown by the fact that it forms an important element in the great deposits of peat which are to be found in various parts of the world.

The Liverworts, the poor relations of the Mosses, are now a comparatively small group. Most of them have broad, flattened ribbon-like stems, which crawl over the

surface of the ground, with small scale-like leaves upon the under side as a rule. The most picturesque of these is the Marchantia, which you will recognise at once by the curious branches that spring up from the main stem on the ground, and look like open umbrellas. Upon these are developed the sexual organs, and the "fruit-plant" is based upon them in the same way as the "fruit-plant" of the moss. Another Liverwort, or rather a group of them, gives an interesting case of joint house-keeping. At the base of the leaves there are small cups, in each of which may often be found a tiny animal called a Rotifer, which draws into the cup, and devours the minute animalculæ that are contained in the moisture surrounding the plant. So far as is known, the plant gets no advantage from the partnership, but these little cups are not produced, as one might think, by the Rotifer, as galls are made by the gall-fly. They are to be found in just as fine a development when no Rotifer is present, but no use has been yet suggested for them, so far as the plant is concerned.

LIVERWORT.

Now we may take another step upward and reach the Ferns.

CHAPTER IX.

FERNS AND THEIR RELATIVES

If we had chosen beauty alone as the basis of our classification we should certainly not yet have arrived at the ferns, for in grace and perfection of form, in purity and depth of colour, they may claim, as a group, almost the highest place in the plant world. Even when we adopt complexity and division of labour as the test, they come very close to the top of our imagined school, and their life history is full of the greatest interest. They have not the unlimited range of the algæ and fungi, and even flowering plants are found to bear greater extremes of heat and cold, but happily for us they flourish in temperate climates. Standing by a waterfall in a wood in England one can picture the scene in those West Indian Islands, where heat and moisture are almost always present together, and where the fern family have their choicest home. If you would realise the kind of atmosphere in which ferns reach their highest development you have but to spend a few minutes in the great fern house at Kew Gardens.

It is true that seaweeds in the ocean depths grow to an enormous size, and puff-balls increase to six feet in diameter to exalt the claims of the funguses; but these are mere masses of simple structure, repeating

again and again just the same arrangements of cells. Not such are the great tree-ferns, with trunk and roots, and a crown of spreading fronds that rivals those of the palm trees. In them we find true complexity, and a steady development to higher things.

The mosses, as we saw, had stem and leaves, but we were as yet among the strictly cellular plants, and the vessels were only foreshadowed by the occasional appearance of a line of cells uniformly altered in the thickness, or shape, of their walls. Now we have true fibro-vascular bundles, and we can trace their ramifications upon the fern's veined leaves. Like those of the monocotyledons, they are generally "closed" (p. 20); that is, they have no cambium ring, making for continued growth and development, but they have learned the secret of combining cells into vessels, and thereby of securing freer and more rapid transport from part to part of the materials necessary for a prosperous life.

And here I must make a digression. When I have used these phrases about plants "learning" or "trying" to do something, I have not meant to imply any theory of plant intelligence. The phrase has been used simply as a convenient expression for the fact of the development of new features.

Whether each plant was inspired with unknown instincts, always aiming towards higher developments, or whether these changes to higher forms are simply the result of the survival of the best-equipped for the battle of life is far too wide a problem to be discussed here. For the present, we may be well contented if we can obtain some general outline of the main facts of the plant world as they now stand. It is only after accumulation of knowledge, not only upon the main

features, but upon every little detail, that we can face the harder problems of the causes that have brought these results to pass, and the principle upon which they have worked. Remember also that when one talks of a "law of nature," this law is not a rule that never should, and never can, be broken, but merely an intelligent summary of a series of hitherto observed facts. It is from observed facts that botanists have drawn their theories as to the close relationship of all plant-life, and the fern group is an excellent illustration. Upon the one hand the tree-ferns, by their structure and growth, lead us on to the pines and firs of the flowering plants; upon the other the filmy ferns, with their thin and humble leaves, lead us back to the mosses.

Again, whilst the appearance of the fibro-vascular bundles warns us that we are approaching the highest forms, there is the backward link of the "alternation of generations" which is, though in a different way, as marked a feature among the ferns as among the mosses. You will remember that the ordinary moss plant was the generation provided with two different kinds of cells for reproduction, known as *antheridia* and *archegonia*, or male and female cells. The fertilised archegonium, to which the snake-like morsel of protoplasm from the antheridium had joined itself, became the "moss-fruit," which, though never obtaining a wholly separate life, had yet in some sort an existence of its own, independent of the plant. You will remember how the spores from this short-lived "moss-fruit," if falling on suitable soil, finally sent up again the branching, conspicuous moss plant, with its sexual organs. Amongst the ferns we still have alternation. The father, so to speak, is not in the least like the son, but the grandson is an exact reproduction of the

grandfather. So far the resemblance is complete; but note the important difference. In the mosses the "plant," the thing we know as moss, is the sexual generation, the "*oophyte*," as it is called, which has a double set of reproductive cells. The generation which produces the spores, the "*sporophyte*," is comparatively insignificant. In the ferns this is reversed. The plant, as we know it, is the sporophyte, and you must often have noticed the brown spore-cases, looking like the eggs of some butterfly or moth, upon the back of the fronds. The generation before it, the generation which comes direct from the spore and is provided with sexual organs, is small and inconspicuous. It is, in fact, comparatively a modern discovery, nor is this surprising when one hears that it is rarely more than half an inch in diameter, and clings closely to the surface of the soil, or even burrows underground.

To get a clear idea of the case let us take the life history of a common fern, and follow its course from its first appearance as a spore. The commonest fern in England is probably the bracken; so common is it that popular opinion in some parts refuses to regard it as a fern at all, and much ignorant mockery is bestowed on anyone who calls it a fern in such parts. Nevertheless, a fern it is, and an excellent type of fern life in most respects. This distinction it has, that it is so hardy that, while flourishing exceedingly in a moist and shady wood, it can also hold its own with success on the sloping hill-side or the open heath, when most ferns would be routed by the dryness and the exposure. Its commonness makes it all the better suited for our purpose, for you can check the accuracy of my account with very little trouble.

Imagine our spore comfortably fallen upon some rotting

leaves and moistened by a friendly shower. At some point the cell-wall gives, and a second cell sprouts from its side. Steadily multiplying cells, it forms a flat plate upon the soil, usually in the outline of a kidney. In this generation we find no leaves nor trace of them, and, of course, no fibro-vascular bundles. Upon the top side it is merely a smooth, green plate, but upon the under side are the structures which will produce the fern plant, and also, driving their way downward, there are root-hairs sucking up moisture and mineral food. This green plate is called the *prothallium*, and, as we mentioned above, it is very rarely more than half an inch across, and usually very much smaller.

You will remember that on the tips of the fertile moss branches we found antheridia and archegonia, the former being round bodies which finally split and allowed the particles of protoplasm to swim off on their fertilising business, the latter flask-shaped, and containing the cells, which, when fertilised, would stay in their place and grow up to produce spores. Exactly similar bodies are produced on the "prothallium," but beneath it, projecting on to the surface of the ground. Very frequently you would only find one kind of body on the prothallium. In that case fertilisation only comes about by means of the swimming protoplasm voyaging along through the moisture of the ground until it finds on some other plate an archegonium ready to be fertilised. This readiness is shown in the same way as with the mosses. The cells that run down the neck of the flask (the swollen part is sunk in the prothallium) all turn to jelly, and the swimmer is attracted to the canal. It may have come off the same green disc, or, more probably, from a neighbour. Gliding down the canal, it combines with the cell

in the swollen part, and the new spore-bearing generation starts.

After a short rest, the original cell splits into several. One of them drives its way into the prothallium, and from it sucks up nourishment—one forms the root into the earth, another the stem, and a fourth the first frond. The work of the prothallium is now done, and when the new fern is established in life, its green frond putting the chlorophyll machinery in action, and its root getting food from the earth, the prothallium, the sexual generation, dies away. The young bracken stem runs prostrate along the ground, sending up frond after frond as it pushes its way along, and flourishing exceedingly. The next necessity is to secure the production of new prothallia, and for this we must have spores. Upon the back of some of the fronds, not usually of all, are developed the spore-cases—green at first, but turning brown as they ripen. In the Bracken, the cases, or *sporangia*, are grouped along the edges of the fronds, and the margin folds back, so as to protect them until the time comes for their dispersal. Then the leaf flattens, and the spore-cases split, allowing the wind to carry the contents where it will. Once more prothallia are formed, and the process we have traced begins afresh.

Now, this life history is true, generally speaking, of all ferns. Each goes through the two stages of existence, and in its more conspicuous stage bears spores upon some or all of its fronds. We have next to consider how to know the different groups to which ferns belong, and this is decided by certain details as to the arrangement and method of protection of the spores. The spore-cases, in the first place, may be grouped on the edges of the fronds, or along the veins, or, sometimes,

at the tips of the veins. A second clue is to be found in the provision, in many species, of a kind of cap or helmet, which spreads like a skin over the groups, and saves them from being carried away too soon by wind and storm. If you notice carefully these two points, you will be able to determine the particular section of the fern kingdom to which your discovery belongs. Then from some larger book of ferns you will be able, by the other details you may notice, to discover the exact variety.

The first group is that of the filmy ferns, whose representatives are scattered over England, but somewhat sparsely, and any one of them is a distinct find. Perhaps the best known is Wilson's Filmy Fern, which we may take as typical. The fronds are very thin and transparent, allowing the veins to be seen very clearly through them. The whole plant has the general appearance of a moss, but the clear veining of the transparent leaves serves to keep it distinct. For the family distinction, however, we must look for the spore-cases, and, if the plant be at the right season, these will be found grouped around the veins as they project from the *margin* of the leaf. The vein projects even beyond the group, giving the plant a slightly bristling appearance, though, of course, the veins are of the tenderest.

WILSON'S FILMY FERN.

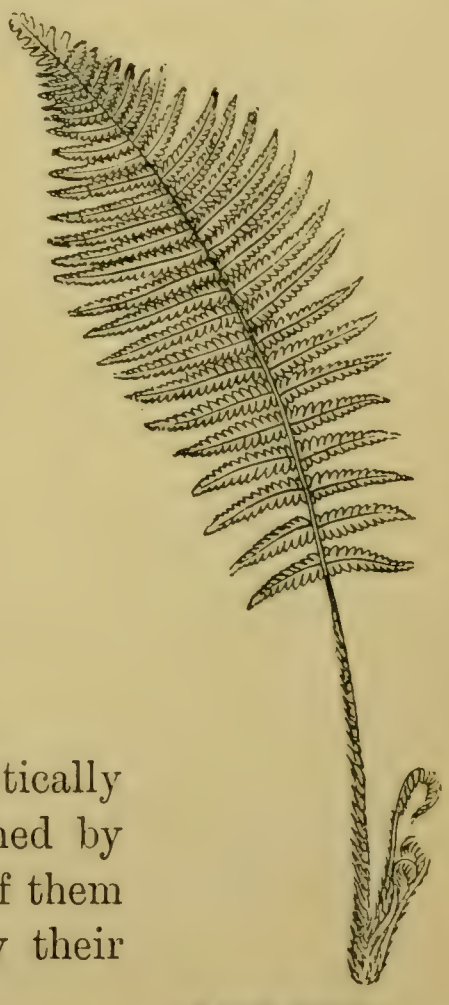
We spoke of the cap or helmet for the groups, but in this case the term is hardly accurate, for the protection takes the form of a cup growing around the base of the exposed part of the vein. As you would imagine from its delicate structure, this group need only be sought in damp positions. The favourite home of a first cousin of Wilson's Filmy Fern is among the rocks about the falls of Killarney.

The next group includes the fern, the life of which we traced in detail, namely, the bracken. Here the spore-cases are posted on the back of the leaf, running close to the margin, and the only shelter provided is given by the edge of the leaf folding back upon them. Besides the Bracken, this group includes the pretty Maiden-Hair, with its black main vein of the frond, and its many wedge-shaped frondlets of the purest green. This may be found wild in some places on the south coast, if search be made in shady caves or rocky waterfalls not far from the sea.

BRACKEN.

The Hard Fern, which also belongs to this section, is easily identified, for it shows a double row of these groups of spore-cases, not quite on the margin, but parallel with the mid-rib of each frondlet, about half-way to the margin. The fronds are deeply indented, but the divisions do not quite reach the main-rib of the whole frond. The leaf folds back for protection of the spores in the same way as the bracken.

The third group takes in a fresh diversity, for in it we meet with real caps of one kind or another. The groups of spore-cases are arranged in small *circular* patches on the back of the leaf, and have a hood which falls off as a rule when the spores are ripe. A good type of this is the common Male Fern, which you may see not only on almost any garden rockery, but in very many woods and wayside ditches. The frondlets are quite separate on the main frond rib, and are themselves deeply indented. The spore-cases are set in double rows along the frondlets, and each cluster is covered with a delicate, round, lead-coloured cap; the thick stem and the tufted crown of leaves make it easy of recognition anywhere.



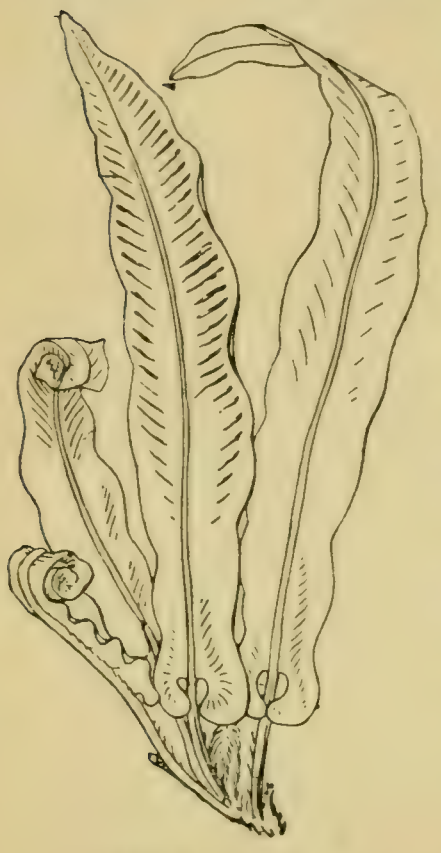
MALE FERN.

Very closely allied to this fern, the leaves of which are annual, are the Shield Ferns, which are practically evergreen. They may be distinguished by their harsh and rigid texture—some of them are quite prickly—and generally by their stouter and darker appearance.

The Bladder Ferns, which have similar much-divided fronds, are recognised at once by the inflated hoods which cover the spore-cases, and are to be sought in mountain districts on damp rocks.

A slight change in the shape of the clusters of spore-cases distinguishes the next group, which includes the Spleenworts, the Lady Fern, and the Hart's Tongue. Instead of circular groups we now find *elliptical* clusters,

which have over them a lid, as it were, also of elliptical shape. The groups themselves, instead of being posted at the *back* of the veins of the frondlets, are at the *side*.



HART'S TONGUE.

Two fairly common spleenworts are the Rue-Leaved and the Sea. The first, with fronds branching into threefold frondlets, is a little plant which may often be found on old walls, with its spore-cases all crowding one another in the centre of the frondlets; and the second, a larger plant of dark glossy green, with fronds that are composed of separately slightly-scalloped frondlets, forms rich masses of colour on the cliffs of the Cornish coast. The Lady Fern is found in much the same localities as the Male Fern, and much resembles it in general appearance; but, even apart from the shape and position of the groups of spore-cases, it may be distinguished by its more delicate texture and its more finely-divided fronds.

The Hart's Tongue needs little description, for everyone knows at once the fern with undivided thick green fronds that one finds everywhere, sometimes on walls, but more frequently where the soil is rich with decaying vegetable matter.

Akin to this group is the curious Scale Fern, in which the hood has disappeared, though the groups are still of the elongated elliptical shape. The place of the hood is taken by a thick coating of scales, which completely covers the back of the frond, and gives it a remarkable

appearance. The hood seems to be represented by a thickening of the vein, alongside which lie the spore-cases. Old walls and ruins generally are a happy hunting-ground for this fern, and they should always be examined carefully by the plant-hunter, who will find a rich reward therein.

The last group of typical ferns is one very clearly marked out and very easily remembered. The shape of the hood need not be kept in mind, for the spore-cases never have any, but are left naked. In this section are the Polypodies, in which the spore-cases are arranged in circular patches like those of the Male Fern, but are left exposed from the very start. The Common Polypody grows very abundantly, and the peculiar shape of the frond, segmented into rows of fingers, serves to distinguish it. The Oak and Beech Fern, on the other hand, have much-divided fronds, and are not so soon recognised. They may be traced to their lair, however, by the fact that the fronds are not jointed to the stem, but are continuous in structure with it. When the fronds die, therefore, parts of them continue to cling to the plant. The Oak Fern has a unique peculiarity. Each frond branches off into three parts of about equal size, the parts themselves being very much divided, and the whole giving a fan-like appearance.

COMMON POLYPODY.

Besides these typical ferns there are three English species which are deserving, for their peculiarities, of special notice. The first is the Royal Fern, which foreshadows the peculiarities of the flowering plants by reserving separate parts of the plant for the special duty of spore reproduction, just as the higher plants reserve seed production for the special parts we know as the flower. The Royal Fern is by far the largest of the English ferns, for it has been found eight or ten feet high, and grows a small trunk, similar on a lesser scale to the tree-ferns of the tropics. From the crown of the trunk spring the fronds, and on the tip of some of these, instead of more leaf-like frondlets, the spore-cases are produced in masses, the whole of the upper part of the fronds being reserved for spores only. In Ireland it is fairly plentiful, and it may be found in England, but the only time I have been fortunate enough to find it wild it was growing in a Welsh bog.

ROYAL FERN.

On a very small scale, for it is usually only four or five inches high, the Moonwort resembles the foregoing. In this the frond splits into two parts. One puts out the ordinary frondlets, set rather closely on the main-rib, each spreading into a semicircular shape. The other branch is upright, and bears spore-cases only, looking like a cluster of very small berries. Peaty pastures are the

spots to be searched, and the fern may be found lying inconspicuous among the grass.

The Adder's Tongue is the third of these eccentric ferns, and perhaps the rarest. Damp meadows are its favourite resort. The frond splits into two parts, as in the Moonwort, but the green, unfertile half remains entire, pointed at the tip and egg-shaped at the base. The fertile section is upright, but, unlike the Moonwort, it does not branch at all, the spore-cases being arranged in a double row along its upper half.

I have called this chapter "Ferns and their Relatives," and these relatives deserve a closer study on your part than we can give them here, for, though not interesting in appearance, in some of their methods they lead us on to the flowering plants, and illustrate the development from one class to the other, and the absence of sharp and definite boundaries to which I have more than once drawn your attention. First come the Horse-tails, which you will recognise at once from the illustration. They all go through the double generation we saw in the ferns; first the flat "prothallium," and then the branching "plant." The horse-tails have adopted the separation of the spore business from ordinary vegetation. Special spikes run up in the spring, usually before the rest of the plant appears, with very little trace of the usual whorls of branches at the joints, and headed by groups of spore-cases. Their work done, and the spores spread, the ordinary shoots come up. Now the whorls

HORSE-TAILS.

of branches spread out freely, and the leaves are represented, though feebly, by the sheath that runs around each joint overlapping the base of the section above it. All the horse-tails take up from the soil a large amount of "silica," or flint, in solution, and deposit quite a bony skeleton within their walls. The fibro-vascular bundles, the attainment of which is the triumph of the fern class, are here very well developed, and, but for the production of spores in place of seed, they would rank in the top class of all.

Club-mosses form another group of relatives, and it must be remembered that, by true classification, these are no mosses at all. The generation we ordinarily see is not that of the moss plant, but of the fern plant, *i.e.* the next generation is produced by a single type of cells, and not by the conjunction of two kinds. The common club-moss, with its long creeping stem thickly clothed with small leaves that look almost like green fur, and its special branches of spore-cases, rising up into the air, and no longer creeping, may be found on any hill-moor.

Both club-mosses and horse-tails have much fallen from a previous high estate, for at one time they grew to a gigantic size. From fossil remains we know that when the forests were flourishing which have now formed our coal-measures, the Horse-tails and Club-mosses had ancestors which grew to the height of great trees, and lorded it over other groups; but now they have come down in the world, and the flowering plants, which developed later, have managed to oust them from their pride of place, possibly because their special attention to the ways of reproduction gave their families a better chance in the struggle for life.

Our last two plants are very inconspicuous connections of the fern family. They are not only retiring in appearance, but also in their residence, for the one lives wholly under water, and the second grows just on the edge of lakes, and is generally submerged the whole winter. The first is called the Quillwort, and the second the Pepperwort. Both have grass-like leaves, but those of the Quillwort are stouter, sharply-pointed, and considerably swollen at the base.

Their interest for us lies wholly in their method of reproduction. In all the other plants mentioned in this chapter the spores are, so far as we can tell, all alike. They give rise to similar prothallia, which may bear both kinds of cells necessary for reproduction, or only one kind, but in either case the prothallium and spore appear the same.

Now, in these two cases, the Quillwort and the Pepperwort, the difference we shall find in the flowering plants between stamen and pistil is anticipated, and they form two kinds of spores. There is a large spore, which forms a prothallium, on which *archegonia* (the long-necked, flask-shaped bodies pictured on page 74) are present, and there are small spores, very like pollen-grains in appearance, which can hardly be said to form prothallia at all. They split up almost at once into the moving pieces of protoplasm (*antherozoids*), which swim off to find an archegonium in which the canal-cells have turned to mucilage.

So we leave the ferns and their company. They have the double set of cells for reproduction which we noticed as a mark of progress, but they have not learned to combine that machinery with the full vegetative life. How that problem has been solved in the flowering plants we shall see in the next chapter.

CHAPTER X.

THE FLOWER AND ITS PARTS (FERTILISATION)

After this hasty and rather superficial account of the humbler members of the plant kingdom, we come to the highest class of all, which includes all the plants we know as flowers, all the trees, and all the shrubs, though less in number than the algæ or the fungi, and not so well fitted as they to endure the extremes of hardship (no flowering plant could live side by side with the red snow—p. 49—nor with that alga which delights in boiling-hot springs), their variety and beauty of form, their complexity of organisation, and their high average of size, give them a commanding claim on our attention. The latter half, therefore, of this book will be devoted to the consideration of this "sixth form" in the plant school. Even then we shall merely have skimmed the surface of the subject, and there will be an infinity of knowledge still to be acquired.

If, as I hope, you may desire to learn more, there is plenty of literature from which you may make your choice. For the mere identification of the various flowers one may find in country walks, there is still no handier book than the Rev. C. A. Johns' *Flowers of the Field, with an Appendix on Grasses*, backed, as it should be, by

the solid Bentham and Hooker. Mr. Edward Step's book on the *Romance of Wild Flowers* is full of information, and should be referred to when the plant has been identified. Finally, when you have learned the "points" of a flower, and know them as a horse-dealer knows the points of a horse, you will find a rich pleasure in a copy, whether borrowed or your own private property, of Kerner and Oliver's *Natural History of Plants.*

In this little book I shall be obliged, by the limits of space, to continue the plan we have hitherto adopted, and to be content with indicating the outlines merely of classification, insisting upon what our groups have in common rather than upon their differences. This is not the place to show how to tell the different parsleys, for instance, from one another, but I would rather set in your memory the qualities shared by all the parsley clan throughout the world.

First of all we must take the flowering plants as a whole, and consider what they have in common, and how it is that we place in one allied class the oak and the chickweed, the grass of the wayside and the gorgeous passion-flower. As was said in Chapter I., complication and division of labour is the basis of our classification, and especially division of labour as applied to the production by the plant of the next generation. We saw how the fungi and algæ might split up at any point, or how any two cells might combine to form the offspring, the whole, as it were, being an ordinary incident of the plant's existence. Ferns and mosses went further, and had generally their double set of cells, and also the curious arrangement of double generations, but in both the formation of fruit was comparatively inconspicuous. Amongst the flowering plants we find a very different

state of things. All produce *seeds*, that is, they form, by fertilisation, *upon the plant itself*, each within a little coat, small *embryos*, which, when they sprout, or germinate, grow into plants *exactly like their parents*. You well remember that the spores from moss-fruits or from the fronds of ferns developed into something quite unlike the generation that produced them. Further, these seeds are always produced by a *double* set of machinery, the machines being of different kinds, and each useless without the other.*

One word of reminder where necessary. Although the seed method is the chief and the typical way of reproduction amongst flowering plants, remember that there is also, even here, a large amount of "vegetative reproduction." (See Chapter V.). We have talked there about the shoots that run underground from the raspberry canes, of the buds of the Celandine, and so on, but in all but a few cases this is merely secondary, and we shall not trouble further with it in this chapter.

In the lower forms we noticed that, generally speaking, any or every part of the plant might add to its other duties that of producing offspring, but at the close of the ferns we found certain examples of special parts of the plant being set aside for the office. The Royal Fern, for instance, only produced the spores at the top of the fronds, and the Moonwort and Adder's Tongue showed a sharp separation of the frond into two distinct halves, of quite different shapes, on only one of which could

* It is true that there seem at present to be genuine cases of an opposite kind, *e.g.* in a species of Bog Mercury, and in certain water plants, but these are so rare and eccentric that for the present they may be dismissed. It is just possible, though it must be confessed improbable, that fertilisation is really accomplished, although it has been impossible hitherto to discover the method.

ANEMONE.

Face page 94.

spores appear. The flowering plants have carried the same principle much further. Seeds are formed only on one particular branch, the flower stalk, and the parts of the flower themselves are composed of peculiarly modified leaves. This is an important point to bear in mind. The flower is not a sudden new appearance in nature, with nothing like it before, but is merely a development of leaves. The proof of this is too long to set forth here, and largely depends upon the evidence given by microscopic examination, but part of the evidence you can

DIAGRAM OF FLOWER.

BUTTERCUP.

note for yourselves. This evidence is given by the "monstrous" or eccentric forms that one occasionally finds in a flower, where part of the usually brightly-coloured section has refused to follow the ordinary procedure, and obstinately remains green and leafy. By cultivation, moreover, the different parts of the flower may all be changed into one type, as, for instance, the wild rose of the fields becomes the gardener's rose, the Buttercup becomes the Bachelor's Button, and the wild cherry is modified into the Double Cherry, which makes an ornamental tree, but, for a reason that you will soon understand, can never produce fruit or seed.

In a complete flower we shall find at most five different types of modified leaves, arranged in circles around a common centre. This centre is formed by the branch upon which the modified leaves are borne, *i.e.* the flower stalk, and the leaves are not distributed over the branch like the foliage leaves, but generally crowded together at the top of it. The names of the five sets of modified leaves are the *bracts*, the *calyx*, the *corolla*, the *stamens*, and the *pistil* or *carpels*.* Upon these last two devolve the essential duties of the flower in producing seed, and unless one or other is present, the flower has no direct use from that point of view. It may be attractive and ornamental, as are garden roses, but for continuing the species it is of no effect in itself, although, as we shall see later, such flowers may help indirectly. Similarly, the outer circles, the bracts, the calyx, and the corolla, can do nothing by themselves, but as guardians of the essential organs, as attracters of the insects which may help them to do their work, they are invaluable.

Let us now examine these five individually, beginning with the outside ring, and working in towards the centre.

The *bracts* are the least modified of the leaf structures as a rule, and do a good deal of the ordinary leaf work with their chlorophyll machinery. They appear at various places on the leaf stalk, and are generally close beneath the calyx, and quite inconspicuous. In some cases, however, they play a prominent part. The ordinary Arum of the hedgerows, which you must know either under that name or as Lords-and-Ladies, or as Cuckoo

* *Bract* means a thin plate ; *calyx*, a husk, cup, or covering ; *corolla*, a little crown, or wreath ; *stamen*, a thread, or fibre ; *pistil* is another form of *pestle ; carpel*, a little fruit.

Pint, has all its spike of flowers enclosed by a broad, closely folded, green, leafy structure, which is a true bract. The compound flowers, such as daisies and thistles, have an envelope at their base of green, dark green or black, which looks like a calyx, but is really composed of bracts. The parsley family, many of them, have a somewhat similar arrangement at the base of their spreading groups of flowers, though in their case the bracts stand out stiffly, like the rays of a conventional sun, and do not form the close coating that we find in the daisy or the thistle. In either of these two cases the circle of bracts is called the *involucre*. Another example of bracts which you have often seen is the cup of an acorn, which is only a fused collection of bracts. The bracts are hardly, perhaps, actually parts of the flower, but they are so closely connected with it that they deserve to be taken first.

We now come to the *calyx*, which holds the flower within it when budding, and supports it when full-grown. It is composed of another ring of modified leaves, each of which is called a *sepal*. These sepals are generally green, as in the buttercup, but are sometimes brilliantly coloured, as in the marsh-marigold. They form the first circle, protecting the essential parts within. Sometimes the sepals are all fused into one complete tube, or ring, with a toothed edge, just showing the original structure, but more often they are distinct and of varying number.

Within the calyx comes the second circle, called the corolla. The separate leaves which compose it are called petals (a short ĕ, by-the-by), from a Greek word, *pĕtallos*, meaning a thin sheet of beaten metal. It is this circle which gives the chief beauty to the flower in almost every case, for it is the chief seat of the various devices

of form and colour with which plants lay themselves out to attract insects. The variations in shape of the petals are, as you know, endless. They may fuse into a tube as in the honeysuckle, mock the shape of a butterfly as in the sweet-pea, sit round in a symmetrical row as the buttercup and the wild rose, or take on such quaint shapes as those of the Snap-dragon and the Calceolaria. Just as much variety is displayed in their colour; every hue, and almost every combination of hues, may be seen in our English flowers, whether growing wild or in our gardens, and almost always we have to thank the petals for it. One colour is never found in England, nor do I know of a case given in foreign floras. We have no flower that is altogether black. We have deep violet, deep purple, and rich brown, but we have nothing like black. Yet, as we know, there are plenty of coal-black insects, black birds, and black animals. For some reason or other, the plant world seems disinclined to follow their example. Perhaps part of the explanation may be that such a flower would not succeed in fulfilling what we shall find later to be one of the chief duties of corollas, namely, to attract insects.

These are the three outer envelopes: the bracts, which are often quite a long way off the flower itself, but always on the flower-branch; the calyx with its sepals, the usually green cup which holds the flower; the corolla with its petals, the usually brightly-coloured crown that surrounds the essential organs concerned with seed production.

To these we must now turn, and we may consider first such a flower as the Buttercup, where the two kinds of machine, the stamen and the pistil, or carpel, are both present.

The outer row of these two is composed of very curiously modified leaves, which we call stamens. This means "threads," and it will give you a general idea of the ordinary stamen, although they vary very much in different flowers. But, generally speaking, we may liken them to walking-sticks with knobs of very various shapes at the tops. The supporting part, which is a delicate pillar of tissue, corresponding to the leaf-stalk, from which it has been modified, is called the *filament*, or thread. The knob is always called the *anther*, meaning "flowery," and this is not altogether inappropriate, for the stamens are essential to the completed flower. Sometimes the middle of the anther is attached at right-angles to the top of the thread; sometimes it is fastened perpendicularly to the top; and sometimes it hangs down from the summit of the filament. In the common Sage the anthers are arranged in pairs, joined by a thick band of tissue, and are set like a dumb-bell upon the summit of the filament. There are just as many varieties of the filament. Sometimes we find stamens, as we also find some leaves, without any stalk at all. Then the anthers are set low down, right on the top of the flower-stalk, and are said to be *sessile*, or sitting. Sometimes all the threads are attached to the petals for most of their course, as in the Primrose, or the filaments may all be joined together, forming an inner tube, with the anthers of course at the top, upon the rim. In spite of all these variations, one cannot fail to recognise stamens; but one word of caution is necessary. There are such things as incomplete stamens, *i.e.* without anthers. These anthers are the modified blades of the leaves, and sometimes stamens only develop the leaf-stalks. Such stamens are of course useless for the purpose of reproduction, but

they may be of indirect use, either as protections, or as guides to visiting insects. In double flowers, the stamens are modified into petals, the leaf-like character of which is still more easily recognised.

We have now to consider what are the chief duties of stamens. You may remember that we found amongst mosses and the prothallia of ferns certain groups of cells which we then called *antheridia*. You may also remember that these split up into *antherozoids*, *i.e.* little pieces of free protoplasm without any cell-wall, that swam about in the moisture of the plant until they found one of the flask-shaped *archegonia* ready to be fertilised, and that then they forced their way down its neck. Now the *anthers*, as their name suggests, have a similar part to play. The disadvantage of the process in the lower plants was that fertilisation could only be secured where there was enough water for these little antherozoids to swim in, and the result is seen in the rather limited distribution of both ferns and mosses. Now the flowering plants have got rid of this handicap. The *anthers* of the stamens, with which they are all provided, produce a crowd of *pollen-grains* (meaning fine flour), known collectively as pollen. The contents of the cells are no longer free, but are provided with a wall. The usual colour, as you may see for yourselves on almost any plant, is a golden, or orange, yellow. These grains are built up inside the *anthers*, which split when fully ripe and let the fertilising grains slip out to perform their part of the task of constructing the seed.

Before we consider how this has to be accomplished, let us go on and examine the other half of the duplicate machinery, namely, the pistils or carpels. As with all the other sets of organs that surround the plant, the

HAWTHORN.

Face page 100.

number of carpels may vary very largely. Further, they may all be separate, as in the Buttercup; or they may be fused together, as in the Tiger Lily. In any case, the structure is divided into three parts by botanists. At the bottom is the *ovary*, which, when fertilised and ripe, we know as the seed-vessel, *e.g.* a pea-pod, or a rose-hip. Within this ovary are the "ovules." These are small preparations ready to become seeds when fertilised. From the ovary the carpels rise up in pillars, either in many or all in one, according to the habit of the plant; and these pillars, or pillar, are known as the *styles* or *style*. At the summit they broaden out into a knob of varying shape, and this knob is called the *stigma*, or point. I want you to remember these names, for we shall often meet them, and it is a good deal easier to talk each time of the "stigma" than "the upper end of the pistil."

Now we have our two machines all ready. The stamens have produced their pollen-grain, and the carpels have prepared the ovules down below. The great problem, and the great interest to us, of all the flowering plants lies in the securing of the union of the two, and the various devices adopted by the plants to bring it about. Unless the two can be made to meet, both the pollen and the ovules will die without doing anything to make another generation. At first sight it would seem impossible, for the ovules are deep down in the heart of the seed-vessel, and the pollen is wandering about outside. Both machines, however, make an effort. When the ovules below are ready, the stigma changes its appearance a little, and becomes sticky. Now is the time for the pollen-grain, and we may imagine that we notice a stigma upon which one of the grains has fallen. How it got there we shall consider later in the chapter.

The stigma is moist and sticky, and the pollen-grain clings to it and sucks up the moisture. It has two coats, the outer one of which is thinner at certain definite points. Through one of these points the inner coat forces its way, and, its contents still included in the wall, it changes its shape into a tube and begins to bore a passage down the style, drawn by some marvellous power towards the ovary. Down and down it goes, searching for the ovules. In each of these ovules nature has prepared a small hole, known as the "*micropyle*," meaning "tiny gate." The pollen-tube passes down the side of the ovary, and then swings up, to find the ovule's tiny gate. It passes through it, and the two cells, the embryo-cell and the pollen-grain, combine their contents, and by some mysterious fashion a new life is formed. The seed is fertilised, and, though not yet separated from the parent plant, begins a life of its own, which we must briefly trace.

For a short time there is a period of rest, but soon we can trace the rudiments of a new plant. Much of the seed is occupied by a reserve of material, with which it may start its new life, the capital given to it by its parents when starting in business for itself. This is stored up in the cotyledons, or seed-leaves, thick and fleshy, which you may see excellently in the young Laburnum plants that start up in the spring. Beside these seed-leaves, one can see with a magnifying-glass other parts of the youthful plant within the seed. A tiny root and a tiny crest of the ordinary foliage leaves are carefully packed away, and the nourishment from which they may develop until they are big enough to fight for themselves and draw their own support from the soil and the atmosphere, is all ready for them in the

seed-leaves. Nor is this all that the parent plant is ready to do for them. Various parts of the seed-vessel become rich and juicy, fulfilling a double end. On the one hand, they attract birds which may plant them far afield; and on the other, which is more important, they help towards a fertile soil, for the juicy envelope will rot away, and the young plants find in it the food they need all ready for them.

It has been seen with what an array of covering the essential organs of the plant are protected in their early days, but the problem becomes more difficult when the flower is opened. The pollen-grains and the ovules are the valuables in the safe, and the ovules always stay in it; but the pollen, as we have seen, has to take an adventurous journey, and is particularly liable to get damaged *en route*. Even in favourable circumstances its fertilising power does not last for very long after it has left the *anthers*. Where it has been carefully preserved from damage, its power may last for perhaps a month or more, but its life is much shorter under natural conditions. Its greatest enemy is water, either in the form of rain or dew, and against this foe all kinds of plant devices are to be noted. Excessive moisture may cause the grains to burst prematurely, or may really drown the protoplasm within. Some flowers are protected by their shape. The graceful drooping bell-flowers allow the rain to drop harmlessly off the outside of the corolla, and one may see other plants imitate their example when rain is coming on. The flower-stalk bends the head, as in the Scabious (or "Devil's Bit," from its blunt root), for example, bends down towards the earth, and the rain-

POLLEN-GRAINS

drops patter harmlessly on the bracts or calyx, which have no objection to the process; in fact, the cleaning from the dust that clogs their action rather does them good. The Foxglove employs another method. If you look at a spike of its half-blown blossoms, you will notice that the buds point upward, but as the flower opens, and the stamens are exposed, the flower droops and points earthwards. The simplest method of avoiding the rain is for a flower that feels it coming simply to close. There is no better instance of this than that of the Scarlet Pimpernel, or Shepherd's Weather-glass, which never opens at all when it is cloudy, and always shuts up at four or five to protect its precious burden from the dew. Many compound flowers, such as the common Daisy, the Ox-eye Daisy, and the Carline Thistle, fold the large outside florets (or little flowers) like a roof over those within; but one may notice that when the flower's fertilising work is done, and it has begun to wither, this power leaves it. How widely spread this power is among flowers you may note for yourselves by comparing any spot that is rich in flowers when a bright sun is on it, and when rain is falling. Half the colour has disappeared. Green calyxes are uppermost now, instead of red and blue; spreading petals have twisted themselves into inconspicuous closed umbrellas, and the glory has departed.

It may be asked, "How does such a flower as the primrose escape, which stares up into the sky, and has a tube in the centre of the flower, which ought to act as a death-trap for the pollen?" The answer is simple. This tube has, as you know, a narrow entrance, and when a raindrop falls on the top of it, the air within cannot escape. It therefore acts as a cushion, and keeps the raindrop resting above it. After a time comes a breath

of wind. The flower swings a little, and the raindrop quietly rolls off.

Sometimes the stamens themselves assist in the process. When damp is felt, the valves which allow the pollen to escape close up, and at least secure what is left. Many flowers are guarded by the leaves, which form, as it were, a slate roof above them, and let the rain slide to the ground. All of these methods, and others which it would be too long to recount, you may notice for yourselves in any garden, or in a meadow where flowers are plentiful.*

Provision against danger on the way, however, does not solve the problem of getting the pollen-grain to the ripe stigma, and we have still to see how this is done. Now a stigma may be fertilised either by the pollen from its own stamens, or by pollen from some other plant of the same kind, *i.e.* by "Self-fertilisation" or by "Cross-fertilisation." The first is the simplest, and the most certain, but it seems to be proved that the latter is more advantageous to most plants. To secure it, many ensure that there shall be no self-fertilisation by having only stamens on one individual, and only pistils on another. Others so arrange it that the two parts ripen at different times, and when the pollen is just ripe, the stigma is either not yet ready for capturing pollen, or it was ready some time before, and has been fertilised by an outsider.

Plenty of plants, however, are content with the simple method, which is easily secured, and the pollen of the flower is deposited on the stigma by actual contact of stamens and pistil. When this method is adopted, the flowers are usually small and inconspicuous, for they have

* Another reason for plants objecting to water in their flowers is that it would wash away their honey, and they could then offer no inducements to insects to visit them.

no need to take trouble in order to attract insects. The most interesting plants are certainly those which have not only the double machinery for producing seeds, but also prefer that the two machines shall come from different individuals. To bring pollen from a neighbouring plant two agencies are employed, first the wind, and second insects, which call on a plant for honey, get dusted with ripe pollen, and then go off to another flower and touch the stigma. As we go through the various types of British flowering plants, we shall meet with all sorts of devices to secure this end, to the pursuit of which we owe the bright hues of our prettiest flowers, and not only their colour, but their scent and their sweet honey. We shall also find excellent examples of the distribution by wind when we consider the Pines and Firs, and the Grasses.

Before leaving this part of the subject I would like to mention two very strange instances of collaboration of plants and insects for their mutual advantage, which are as curious as the lichen partnerships of algæ and fungi discussed earlier. They may very well be mentioned at this point, for both plants are foreigners, and we should not meet them again in the study of our English families. The first is the case of the Yucca plant and a moth that frequents it; the second that of the Fig tree and a kind of gall-wasp.

The Yucca is a plant that you may have seen in Botanical Gardens, bearing a tall spike of greenish-white flowers (or occasionally of another hue, according to specific variation). These flowers are specially attractive to a night-flying moth called Pronuba, and in their turn they depend upon it to be fertilised. They therefore reverse the usual process of plant-life, and their bell-

GERARDE'S DOG VIOLET.

Face page 106.

shaped flowers, which are closed all day, spread out their petals when dusk comes on. As the petals spread, the *anthers* split and expose a sticky mass of pollen. The moth comes round, and promptly gets to work. It crawls over the stamens and picks up piece after piece of the pollen, carrying it all, rolled into one mass, in what one may call, perhaps, its jaws. So sticky is the pollen that there seems no chance of its getting naturally to the stigma. You will remember that deep down in the pistil are formed ovules, which the fertilisation by means of the pollen-tubes is to turn into seeds, but which, without the arrival of the tubes, will wither away and die. Well, after collecting this ball of pollen from the stamens, the moth flies to the pistil. Deep down in the base, close to the ovules, she lays some eggs, which in course of time will turn to caterpillars. Then comes her question, what are they to feed on? The reply is, "The Yucca seeds." And now one sees the object of the pollen collection. To ensure that the ovules shall become fertilised the moth now flies up to the stigma and fixes the ball of pollen to it; the tubes run down the shaft of the pistil, and reach the ovules. You may say, "Where does the plant get any advantage? What is the good of making seeds in order that a caterpillar may eat them?" The plant's reply would be, if it were able to argue the question, "The caterpillar will be fully fed by twenty or thirty of my seeds, but that ball of pollen will send down tubes to two or three hundred ovules, and I can well spare a few seeds to keep up this most useful race of moth." The moth in its turn might contend that it was very well suited by the arrangement, that its children were supplied with suitable food and complete shelter, and that, if it suited the plant, so much the better!

All this sounds like a fairy tale, but the Yucca has been watched as it opened for the moth at dusk; the moth has been seen acting as I have described, and experiment after experiment has gone to show that the Yucca can produce no seed without the help of the moth.

In the case of the Fig, the process is rather different. All the flowers grow closely crowded together, as it were, upon the inside of a flask, the neck being closed by a scaly arrangement, through which an insect can push its way. Near the top of the flask, or urn, the flowers consist of stamens only, but lower down there are flowers with pistils and no stamens. These pistils are of two kinds, one being much shorter in the shaft, or style, than the other. Within the short-styled ovary is a gall-wasp, which in time comes forth full-blown, and struggles over the stamen flowers to the mouth of the flask, covering itself with pollen in the effort. Then it crawls off to another flower, or rather, group of flowers, in order to lay eggs. Forcing its way into an adjoining flask, it passes down to the pistils and leaves some pollen upon those that are ripe, though not in this case, as with the Yucca moth, of set intention. It also proceeds upon its main business and lays its eggs promiscuously in short-styled and long-styled flowers alike. And here we find a most ingenious device. The long-styled flowers are protected from the gall-wasp, for it cannot set the egg deep enough to get at the ovary, and in the ovary new seed is safely produced; but the short-styled flowers suit it admirably, and a fresh generation is produced to fertilise other fig trees. On the other hand, it would be a waste of energy for these short-styled flowers to make seed which would be eaten up, for they are not necessary

as a gall-wasp's food. The short-styled flowers, therefore, have no power to produce seed, even when pollen is put on the stigma. They have simply developed into suitable homes for the particular insect which is a necessary fertiliser of the real seed-producers, the long-styled flowers.

CHAPTER XI.

THE CONE-BEARING PLANTS

FLOWERING plants are obviously too large a group to study without any attempt to split them up into sections, and Nature has cut off one important group by a very clear distinction, to which I made reference in Chapter I. The Pines, Larches, and Firs, with their close allies, the Juniper and the Yew, although they have flowers, have not developed the seed-vessel. Their seeds are placed naked or exposed at the base of the pistil, and so they get their name of *Gymnosperm* ("undressed"), a word allied to our "gymnastics," from the costume, or the lack of it, in which the Greeks raced and wrestled.

You will recall how the pollen-grain, falling on the stigma, thrust out its tube, and bored its way down the style, until it came to the ovary, and then made its way to the *micropyle*, or tiny gate, which was left at the mouth of the embryo seed. The process is very much simpler with this group, for the "micropyle" is exposed direct to the air, and the pollen-grain falls direct upon it, and its tube starts on a much shorter journey. From the illustration, you will get a clear idea of the method, and you will be reminded of the family we have just left, the ferns. There we saw a *prothallium*, in which there were flask-shaped bodies, the *archegonia*, and you remember how, at

the proper time, the neck of the flask dissolved away, and left free passage for the swimming *antherozoids*. Here we have the same flask shape, with the narrow entrance at the top, and the whole mass of cells that clings to the scale of the cone corresponds to the Fern's independent prothallium, though never, in this case, possessed of independent life. Settled upon the micropyle, which is sticky, like the top of a ripe pistil, the pollen-grains send down their tubes, which find the waiting ovules and fertilise them. This fertilisation is rather a long business, for very often the pollen-tube takes two years to make its way from the micropyle to the embryo seeds, lying inactive through the winter.

WINGED CONIFER SEED.

In this family, the male flowers (those with stamens) and the female flowers (those with pistils) are never combined, but are grouped together in separate masses. The male flowers form tassels, or catkins, which disappear when they have shed their pollen; and the female flowers, with the seeds, remain on the tree, and harden into the well-known cones. Very often the stamens and pistils keep to separate trees, and in any case you will see that the pollen has to make a voyage of some extent. Happily Pines and Firs are not, like Mosses and Ferns, dependent on the presence of water for the conduct of the voyage, for they have adopted the "pollen-tube" method, which allows of wider transport, and their pollen-grains are easily able to travel, if they can find a suitable agent. They are separate from the pistils, so cannot get to the seeds by simple contact, and they have no bright hues nor sweet honey to attract insects. There is only one carrier

left, and that is the wind. As from all plants that depend on this rather erratic agency, a very large supply of pollen is required, and it must be of a particular kind. It is obvious that many sorts of wind are of no help to the plant. The gale that comes with a soaking rain will certainly drown the pollen, and will probably also carry it too far, to some place where, so far as our conifer is concerned, it will be wasted. It may not be wasted, nevertheless, so far as plant-life as a whole is concerned, for when we were talking of algæ, we found that the "Red Snow," as it is called, drew much of its living from the decayed and wind-borne pollen of neighbouring Swiss pine-forests. What the firs require is a gentle breeze that will carry their pollen, which is a dust like the very finest flour, up into the air in a uniformly distributed cloud, to let it fall again gently on the waiting cones of seed embryos, which, as you may see for yourselves, are almost always posted upon the top of the trees, whilst the pollen-bearing flowers tend to crowd the lower branches.

The amount of pollen that can be shaken out of a ripe stamen flower is simply astounding, but it is to be explained, like the vast number of the eggs of a fish, by the fact that only a very small proportion will succeed in life. The difference in wind-borne and insect-borne pollen is worth emphasising. Such pollen as we are describing is very fine, light, and dry, the Pines even providing their pollen-grains with air-bladders to enable them to float more lightly in the air; but when insects have to do the carrying, we find the grains armed with hooks, to cling to the insect's hairs, or close-grouped in sticky masses.

I have insisted so far chiefly on the difference in the seed by which Pines and Firs are marked off from other flowering plants. Now let us look at their flowers again,

and see how they rank in this respect. Upon the whole they are very insignificant. The tassels and cones form a fairly conspicuous group, but the individual flowers are of little account. The calyx and corolla, upon which we usually have to depend for showy colour, are not yet in evidence, but the "bracts" are of great importance, for they form the scales of the cone, behind which, as one peels them off from the branch, one sees the embryo seeds and the inconspicuous pistil, or carpellary leaf.

Quite apart from their flowering arrangements, the conifers are a very well-defined group, and one can recognise them almost invariably with very little trouble. The majority are evergreen, that is to say, their leaves last for more than one year, and this alone renders several of them conspicuous in an English winter; and all have a characteristic tendency to put out their branches in whorls, or circles, around a tall and tapering trunk, though this is better marked in some groups, *e.g.* the Spruces, than in others, *e.g.* the Juniper. Above all, they are distinguished by the peculiar shape of the leaves, which are well known as pine or fir "needles," and which, when fallen, form dense carpets beneath the trees. The tree trunk grows in the same way as do those of the Dicotyledons, namely, by the formation of a "cambium ring." (See Chapter III.) The fibro-vascular bundles are "open," and the trunk thickens uniformly. In this particular they come close to the highest and latest group of plants, but, on the other hand, the remote ages to which we can trace their fossil remains, and the resemblance to the Club-mosses and Horse-tails in their flowering methods, indicate that they are the most ancient form of flowering plants, and, as such, come first for examination.

So much they have in common. We may now consider the chief features of the groups into which they are divided, and the first group seems, on a superficial examination, to lack some of the true characteristics. This is the well-known Yew tree, the dark green foliage and juicy crimson berries of which are a conspicuous object everywhere. It must be confessed that, as a cone, the ripe fruit is rather a failure, but the method of branching and the long thin leaves bear witness to the family relationship; and if you examined the tree in the flowering season you would have no hesitation in what class to put it. The staminal flowers and the female flowers are then both of the cone type. The first are roundish, and the stamen tops expand into a hard, woody shield, with wrinkled edges, sheltering the precious *anthers* until they are ripe for the pollen to go on the breeze. Then the shields separate, and through the cracks the pollen dust escapes. If, however, rain should come on, the shields expand again, and the pollen is protected. The female cone has the peculiarity of containing only one seed, and the *micropyle* hardly deserves its name, for the opening is quite wide. A section of the unripe cone will give you an idea of the arrangement of the scales. As the seed ripens the envelope becomes red and juicy, and the bracts that, in an ordinary cone, are so well marked, sink into a little scaly cup at its base.

YEW SEED.

Nowadays the yew is, like modern archery, purely ornamental, but when the bow was the national English weapon, winning battles at Falkirk against the Scotch, and at Crecy against the French, the growth of the yew was a matter of great public interest, for no other wood could compare with it in the making of bow-staves. It

is probably to this demand that we may attribute the number of old yews to be found in churchyards. The foliage is so poisonous that it was not safe to have the tree where cattle could get at it, but in churchyards it could do no harm. In many parts of the country one may find these relics of the past, and I cannot resist the temptation of giving you Wordsworth's description of the

"Yew tree, pride of Lorton Vale,
Which to this day stands single, in the midst
Of its own darkness, as it stood of yore ;
Not loth to furnish weapons for the Bands
Of Umfraville or Percy ere they marched
To Scotland's heaths ; or those that crossed the sea
And drew their sounding bows at Azincour,
Perhaps at earlier Crecy, or Poictiers.
Of vast circumference and gloom profound
This solitary tree :—a living thing
Produced too slowly ever to decay ;
Of form and aspect too magnificent
To be destroyed. But worthier still of note
Are those fraternal Four of Borrowdale,*
Joined in one solemn and capacious grove ;
Huge trunks ! and each particular trunk a growth,
Of intertwisted fibres serpentine
Up-coiling, and inveterately convolved. . .
. . . . . A pillared shade,
Upon whose grassless floor of red-brown hue,
By sheddings from the pining umbrage tinged
Perennially—beneath whose sable roof
Of boughs, as if for festal purpose, decked
With unrejoicing berries—ghostly shapes
May meet at noontide."

However, the exploits of the yew bow-stave, and the poetry of the tree, lead us too far from our Pines and Firs, many of which still await an introduction to you.

* No longer four, alas ! in 1902.

The monkey-puzzle probably hardly needs one, except under its technical name of Araucaria; but, being an alien in this land, it is not very often fertilised. Its cones are large and spherical, of about the size of a cricket ball, and form very conspicuous objects, when they do occur, at the extremities of the candelabra-like branches.

The Coniferous trees found in England may be divided into five great groups: (1) the true Firs, including the Spruces; (2) the Larches; (3) the Cedars; (4) the Pines; (5) the Cypress and the Juniper.

The Firs and Spruces may be distinguished at once from the Pines by the cone, which is composed of uniformly thin scales, whereas the Pine cones have much-thickened tips to the scales. Another clue to identification is given by the arrangement of the leaves, which, in our present class, are found to be produced singly, direct from the branches, whereas the Pines have their leaves in groups of two or more, the base being enclosed in a little scaly cup. Firs and Spruces may be distinguished from one another again by the cones and leaves. In the Firs the leaves are flat, and have white streaks on the under side. In the Spruces the leaves are prismatic, with four angles. True fir cones do not drop off entire, but shed their scales one by one and stand erect upon the tree. The spruce cones hang down when fertilised, and the whole cone comes away in one piece when the seed has been shed. The best-known English sample of the true fir is the "Silver Fir," the bark of which, in youth, is smooth and silvery grey, though it becomes rough and discoloured with age. The magnificent Norway Spruce, with its long and sweeping lower branches, and, in favourable localities, its towering stem, is a fine type of the family. To the Norway spruce we are indebted for most of our scaffold poles and pit props.

A Larch, in winter at any rate, is very easy to identify, for its leaves fall off, and its circular branching will distinguish it at once from our other forest trees. Its cones are true fir cones, with thin scales and an erect growth, but it may be distinguished by its leaf arrangement, which is of two kinds. On the new shoots the leaves are single, but on the older branches they appear in whorled tufts.

A Cedar is not likely to be confused in England with anything else, for its mass of dark foliage and heavy, sweeping branches make it, when full-grown, unmistakable; but a young one may be identified by its resemblance to the larch in the leaf arrangement, and by its difference from the larch in darker colour and leaves that persist for two years.

The Pines are the hardiest and widespread of all the Conifers. Some of them have been induced to make a home on the shifting sands of the Landes in the south of France, and have made what was a waste a valuable timber property. Rugged mountain slopes and barren heaths seem to be alike to them, and best known of all is the Scotch Fir, a name typical of the misleading nature of much popular terminology. It is not a true fir at all, but a *Pine*. The leaves are grouped in pairs, each springing from a sheath; the cones are composed of thickened and hardened scales, and the tree is in all ways a true pine. It is interesting to note how it seems able to make a living in poor tracts of the New Forest, where oaks and beeches have never been able to get a fair start. The hardy and economical Scotchman manages to wrestle his way through, and the open heath begins to be dotted with small colonies. Besides the other distinguishing marks of a pine forest, we may mention the

rich red trunk, which contrasts superbly in a pine wood with the green foliage of just the same depth.

The Cypress group includes rather widely differing forms. The "sad cypress" itself has not the needle-shaped leaf, but the tree, which grows very much after the manner of a poplar, is clothed with small, shining green, scale-like leaves. Its cones, which are spherical and about 1½ inches in diameter, mark it out at once by the peculiar shape of the scales when ripe. The top of each scale is swollen, somewhat after the fashion of the wrinkled shields of the Yew stamens, but of course on a larger scale.

As we opened our cone-bearing plants with a berry, so we may close them, for the Juniper cone-bracts, when ripe, become juicy and join together to form a rich dark berry, used to flavour spirits, and giving their name to gin. The English Juniper is a shrubby and thorny plant, which may be found on chalky commons (*e.g.* Moulsford Downs), and which looks a rather degenerate specimen of the family, but it has near relatives that supply useful timber. For instance, the red wood of which cigar-boxes are made is the product of an American Juniper tree.

As to the practical importance of the whole family, a moment's thought will make you rank its members very high. In boat-building, ship-building, and house-building, deal and pine are used. If a flour-mill is supplied with new machinery, red pine is called in for spouts and elevators. Nearly every floor in a room has deal boards, and much of our oak and mahogany furniture is backed up by deal. Since, in addition to this, they clothe mountain sides, and keep green and look as cheerful as they can during winter, we shall agree that they are worthy of closer and more individual attention than most of us are in the habit of giving to them.

CHAPTER XII.

GRASSES AND SEDGES

Our next two chapters have to deal with the "monocotyledons," *i.e.* with plants that have one leaf developed in their seeds. This in itself, as I have already told you, is a trifling point, but with this go usually certain other peculiarities. In English monocotyledons no cambium ring is ever found thickening the stem year by year; in fact, the stem aboveground dies down every winter. One feature by which a monocotyledon can at once be recognised is the parallel veining of the leaves. The main veins run side by side down the leaf, which is almost invariably quite simple in shape, and not carved and scalloped as are the leaves, for instance, of the Herb Robert, or, in another fashion, of the Dandelion. In the Dicotyledons the veins form a branching network over the whole expanse, and their example is followed by one eccentric member of the present family, the Herb Paris, which we shall meet again later. Another point that may reasonably make you suspect a plant of being a monocotyledon is the appearance of the flower. If the various parts that were mentioned in Chapter X. show a partiality for the number three; if there are three sepals and three petals, or, as may happen, six structures that might be either, it is well first to hunt amongst the

monocotyledons for its identity. The seed, of course, would give certainty, but one does not always find the seed with the plant, and, even when found, its dissection is a work of some delicacy. Beside the mere incident of possessing only one cotyledon, however, the seed possesses something of much more importance to us, and that is a very large reserve store of nutriment for the young plant in the shape of albumen, which happens also to be eminently suitable nourishment for ourselves. In the Dicotyledons this nourishment is usually taken up into the embryo before the seed leaves the parent plant, but in this group we find it at our own disposal.

A moment's thought will show the vast importance of this peculiarity, which is especially prominent in the Grass group now under consideration. At first sight one is inclined to neglect the grasses, so common are they and so very much alike. But when you think for a little on the number of folks that eat rye or wheaten bread, of the vast consumption of maize, of the fact that nearly half the population of the world makes its staple food of rice, another grass-seed, and that the sugar-cane is a big grass, you will agree that the family, if not exciting, is extremely useful.

Not only for our ordinary food, but for most of our ordinary English pleasures, we depend on grasses. Without them we should be robbed of cricket and football fields, of tennis lawns and bowling greens (for asphalte is but a poor substitute for the springy turf), and the hunting man would lose three-quarters of his joy.

Another virtue of the grass is the way in which it prepares the ground for other plants. For instance, on the east coast of Norfolk, upon the shifting sand hills that fringe the sea, and seem likely not to be able to

BLACKBERRY.

Face page 120.

support any vestige of life, so dry and barren are they, the marram grass is slowly making its way, binding the loose sand together and holding it against the winds. And where the grass has made good its hold for some years, it has made life possible for other plants. Seeds of sea-pinks, that would have perished miserably but for the shelter given, have been enabled to sink their roots, and are now varying the rather commonplace marram grass with their bright tufts.

I do not here propose to attempt to distinguish between the 120 species of native grasses that we can boast, but I would most strongly advise that, if and when you begin collecting, you should not neglect them. They will well repay any amount of trouble, and will certainly cause it. Owing to their close relationship to one another, and perhaps to the fact that they are casually fertilised by the wind, one meets with many forms that can only be explained as hybrids between closely-allied species.

The general type of the grass family is uniform enough, whether it be the giant Bamboo rising to 170 feet, or the tiny grass that springs up at short notice even in the cracks between the paving-stones of a town roadway. The stem is almost always hollow, with solid nodes, or joints; that is to say, the tube is intersected at the joints by a plate of strong tissue, which may be supposed to strengthen it. The leaves are always long, thin, and pointed, with this peculiar feature, that they do not join the stem really at the point at which they appear to leave it, but run down it with a close embrace to the next joint, concealing the stem from sight. Thus, we never really see any part of the grass stem, except that which bears the flowers. By the character of this embrace the grasses are distinguished from the sedges. The former

grip the stem with the edges of the leaf folding over one another, and the leaf can therefore be unfolded and removed from the stem without damage. Amongst the sedges, on the other hand, the lower edges of the leaf are soldered into a tube, and, of course, if the leaf be pulled away, the tube is torn.

The flowers are borne in spikes, or ears, and appear in very varying numbers, from hundreds down to as few as twenty, and are all marked by strong family resemblance, distinguished easily enough from other groups by the entire absence of either calyx or corolla. (In the grass group I here include the sedges, the reeds, and the true bulrush. This is not the reed-mace or poker,* but the tall plant with a feathery fan of flowers, which grows so plentifully around all the Broads, and along many of the rivers of Norfolk and Suffolk.) We can at once separate the true rushes (the *Juncaceæ*) from the grasses by examining their clusters of flowers with that low-power magnifying-glass, which you should always carry with you when out botanising. In the rushes we find that the flowers have got a definite whorl of floral leaves around the stamens and pistil, although they are small and coloured a quiet brownish-green.

In monocotyledons especially there is often no clear line between the calyx and corolla, and when there is only one ring present people may and do differ whether the calyx has disappeared, or the corolla has disappeared, or whether they have simply fused into one indeterminate ring. Well, as I said, the grass flower is recognisable at once, for the perianth is generally entirely absent. Sometimes we find two small scales lying close by the stamens

* In which the perianth, or envelope formed by calyx and corolla combined, is represented by scales.

and pistils, which have received the name of "lodicules," and are supposed to stand for the corolla. This raises a very interesting point for the Evolutionist. Are we to suppose that our grasses are the first step upward in flowering plants, and that these tiny scales are the germs from which the gay corollas of lilies, orchids, and the like have sprung; or are we to think, as some do, that they are their degenerate representatives?

Although we do not find our "floral envelopes" in grass flowers, you yourselves know that the essential parts are not left unprotected, for an ear of wheat will show us that there is a good deal upon the flower-stalk besides mere stamens and pistils. At this stage of flowering plants, bracts play a great part, and if we take the aristocratic wheat as the type of the group, we shall get some idea of their arrangement. Each spikelet on the ear branches a little, and bears two or three flowers at the tips of the branches. At the base of the spikelet are two bracts, which have small sterile flowers where they join the flowering stem. These bracts are called in the grasses *glumes*. Going up the tiny branchlets, we find another bract, called the *pale*. The mid-rib of this is often prolonged into a long stiff point, which is called the *awn*. This awn is very clearly seen in the Bearded Wheat or Rivetts, which you may see cultivated on many of our farms, especially in the Midlands. Still climbing up, we come upon another bract, to which the flowers themselves are attached, and this is called the *flowering pale*. In some kinds of grass, *e.g.* Barley and

WHEAT FLOWER.

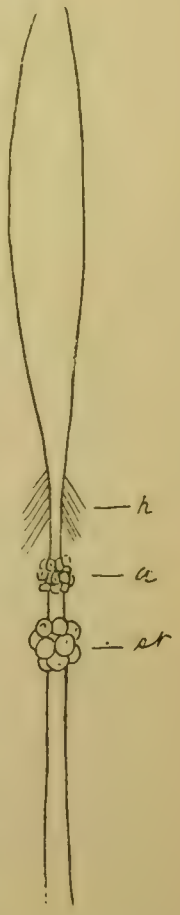
Oats, these pales cling tightly to the seed and form the husk, which, as you know, takes a good deal of removing. In wheat, on the other hand, the husk falls away very readily and leaves the seed clean and bright. The stamens have long threads or filaments, and the anthers hang outside the flowers, as you may see in a wheat-field in May or June. The pistils have only one embryo seed at their base, and the stigma (the top of the pistil) is cleft into three parts, each being feathery, so as to catch the pollen when the wind blows it along, for, as these flowers contain no honey, insects have no temptation to come to them and transfer the pollen.

Let us, in imagination, watch the process of sending out the pollen from the stamens. When the anthers are fully ripe, the bracts open at a regular time in the day (with wheat this is about five or six in the morning), and the filaments of the stamens promptly grow at an astounding pace until they have put out their anthers well into the wind. At the same time the anthers split down the side, in order to allow the pollen to escape. But there is obviously a great danger to guard against. If the morning is perfectly calm, the pollen might simply slip down to the ground and be wasted, for the pistils and stamens on the same flowers do not ripen together. To avoid this, the lowest part of the anther curls round and takes the shape of a tiny spoon, into which the pollen falls. Then, when a breeze comes, the anther swings in the air and secures for its pollen at least a chance of doing its proper work. You will see at once how important is a good flowering time to the farmer. If there should be no wind at all, much pollen would be wasted, and if heavy showers should come for a long time, the pollen will be drowned out altogether. Against

this latter danger the plant makes another provision. On the approach of damp the valves of the anther, feeling the damp, close up, and no more, for the time, falls into the spoons at the base. What is already there has to take its chance, but at least the risk is minimised, and the whole stock is not allowed to perish.

If, as I hope, you may begin to collect, and wish to know what your grasses are, there are two books you will find useful. For a beginning, get one of the later editions of the Rev. C. A. Johns' *Flowers of the Field, with an Appendix on Grasses*, and for a more elaborate work you may consult the eleventh volume of Sowerby's *English Botany*, which is devoted entirely to this group.

I will conclude this chapter with a brief description of a very common, but most interesting plant, which has on the one hand certain affinities with the grasses, and on the other leads us up to the orchids and lilies, which are to form the subject of the next chapter. One of the first flowers that you come to recognise is the common Arum, either under that name, or as Cuckoo Pint, or as Lords-and-Ladies. By any hedgerow in the spring-time you may find the broad, glossy green leaves, sometimes spotted with purple, and in the centre the quaint spike of flowers, close wrapped in a green shroud at first, which soon unwinds, and exposes the dull purple or creamy club-shaped top, and the clustering rings of flowerets around the base of the pillar. Equally conspicuous when winter comes are the clusters of coral-red berries, raised up on the fleshy stalk from the herbage of the hedge-bottom. These same berries, by-the-by, are held, and I believe truly, respon-



SPADIX OF ARUM.
h. Hairs.
a. Anthers.
st. Stigmas.

sible for many cases of poisoning of children, who have been unable to believe that such bright colouring was not a sign of fine flavour. Probably the present generation does not read Mrs. Turner's *Cautionary Stories for Children*, with their Draconic punishments and a death-rate worthy of the last scene in Hamlet, but there is one delightful couplet in the dreadful story of the fate of two infants, which always pleases me.

> "Now had these children understood
> That fruit in lanes is *seldom* good,"

they would not have expired in such awful agony as is assigned their portion for a solemn warning.

However, to return from the high regions of moral philosophy to our plants, let us examine the Arum a little more closely, with the help of the illustration. The club-shaped purple top is *not* a gigantic pistil, as one might be tempted to imagine, but only a prolongation of the flowering stem. Its colour and its smell are supposed to attract the flies which are to help in fertilising the flowers, as we shall see in a moment. The first ring, going downward, is composed of modified stamens, which have no anthers, and produce no pollen, but are set around the club and form a fence of stiff bristles, pointing downwards and spreading outwards to the sheath, which is itself a big bract. Beneath these bristles come the true stamens, and beneath them the ring of pistils and embryo seeds.

Fertilisation here would seem a very easy matter, for the pollen might simply drop down upon the stigmas below. But the arum plants do not take this course. They have found (to put it figuratively) that it is best to get pollen

from a neighbouring flower, and the whole mechanism of the plant is arranged to secure that end, self-fertilisation being avoided by the simple provision that before the anthers shed their pollen the stigmas are too old to receive it. In the first place, the carrion smell of the plant attracts flies, which come hoping for a feed on their particular luxury. Let us suppose that they have visited an Arum plant, been dusted with pollen in the way I shall soon describe to you, and have flown off to another. The open sheath shows them the way in, and they easily push their way downwards through the bristles, and look for their expected carrion. Round and round the bottom they run and of course leave the pollen they have brought upon the stigmas, over which they climb. Thus the first part is secured, but the second remains. These flies are wanted to carry away pollen to other plants, and, if the stigmas were ripe to receive pollen, the anthers could not be ripe to shed it. Now comes the office of the bristles. The flies, in disgust at finding no carrion, try to get up, but the bristles point against them and they cannot force their way up. There they must remain until the anthers ripen. When these have split, and dusted them thoroughly, two modifications are seen at the same time in the flower. Honey is produced at the stigmas, which encourages the flies to seek other arum flowers in spite of their experience, and the hairs or bristles, now their work is done, wither away! So the flies are released to repeat their experiment.

Now, whether these flowers were created with these devices at the very beginning, or whether through countless generations and by infinite experiment these various forms have been evolved from one common origin, this is

not the place to discuss, but it certainly does seem to me that the latter view imposes an, if possible, even higher measure of reverent admiration for the designing and controlling Power.

CHAPTER XIII.

LILIES AND ORCHIDS

The flowers which we have to consider in this chapter form a startling contrast to those of the grasses. In them we found no calyx or corolla, or at best these were represented by tiny and insignificant scales. Interest there might be in the structure of the flower and in its working, but of striking beauty there was nothing. Now we pass at one bound to the most gorgeous and resplendent of our British plants. For sheer loveliness of form and colour in flower there is, among our wild flowers, nothing to rival this second group of the monocotyledons, although, if we include plants that are cultivated, the blood-red crimson splash made by a field of sainfoin clover upon a landscape might come near in the contest for pride of place.

Just recall one or two scenes in which this class of flowers plays a prominent part. We are standing in summer in the Fen country, on one of the long river-banks which save the fertile soil from being drowned, and from it we look over miles and miles of farm-land, the scanty houses dotted about, often protected by a clump of tall poplars. Here and there a windmill's sails speed merrily round, working the pumps that lift the water from the drains to the higher level of the

river. In the distance the sky-line is broken by a grey church spire, or, if we be in Norfolk, by a square-cut tower, the only landmark for any but the native of the county. Straight-drawn across our view runs an invading railway, disregarding all obstacles. In the slow drain, the waters of which creep along upon the outer side of the river-bank, we may see the pinkish bloom of the Flowering Rush, the delicate crimson-centred flower of the Arrow Head, and, above all, the flaming yellow of the Flag or Iris. There it stands in groups, its grey-green, sword-shaped leaves combining in beauty with the spreading golden crown of the flower and the dark-brown, peaty soil of the fields beyond.

Another scene comes to mind of a wood in the fresh green of spring, carpeted with hyacinths, the flowers of which rise like a blue mist of colour above the herbage round the trees, while over and about them hover all the insects that have risen from their winter sleep. Before the hyacinths are gone we may find, gracing a shady corner, the delicate bells of the Lily of the Valley, and perchance, before the Hyacinth came, the snowdrop might have been seen, throwing up a tender flower almost before the first hint of spring.

The cliffs and headlands of the Cornish coast are brightened in spring and autumn by the bright blue stars of the Squill, which revels in the warmth and dampness of the western climate; but perhaps the flower which brings the most perfect pleasure of all is the pale, yellow, nodding Daffodil, with its still paler tubular corona, guarding the precious pollen. To see this flower in perfection one must go northward to the Lake district, and there, in the Duddon valley and elsewhere, one feels what inspiration Wordsworth had at Ullswater, and how

grandly he used it. The stream goes tumbling over rock-strewn slopes; the trees are just opening their buds, and clothing the hills, until they rise to the mountains at the head of the valley, where no trees may be, and all the level surface at the foot is carpeted with "a host of Golden Daffodils, fluttering and dancing in the breeze."

Still keeping to this same group, we find included the quaintest flowers in all nature, the great Orchid family. Of these we have not many common varieties in England, and a dozen or so will complete the list you are likely to find in casual wandering; but if you would see of what the family is capable, go to the Orchid House at Kew in the summer-time, and examine all the fantastic shapes, the brilliant colouring, and the mocking imitation of insects that are around you, and then I think you will agree that for wonders of the flower alone this group has no equal in plant-life. Sepals and petals alike take their share in the glory. The calyx is not sobered down to green, as in the majority of flowering plants, but both of the protecting envelopes take their part in the brilliant display. We have left the sober grasses with one step, and most certainly Solomon in all his glory was not arrayed like one of these.

But here an objection may be raised. You will say, "It was stated in the first chapter that the production of seed was the great test upon which classification was settled. If these are the most beautiful flowers in the world, why should they come here, and not at the last, as the climax to which we at last arrive?" The answer is that these flowers have just the same *essential* parts as the grasses, and as those to which we shall come later,

viz. they have stamens and pistils. Their splendour is due to the development of subordinate and, comparatively speaking, unimportant parts, the calyx and corolla. All these beauties are, above all, contrivances to bring insects to carry the pollen from one flower to another, and the general principle of fertilisation is in no way modified. On the other hand, the plants as a whole are not so advanced as the Dicotyledons, and they have the same limitations as the grasses. The seeds, of course, have still one seed-leaf; in almost every instance the leaves are not complicated by division, and, which is most important, their growth is limited by the mode of growth of the fibro-vascular bundles. (See Chapter III.) The cambium ring is not formed. As another guide for recognising the group, remember that the veins of the leaf are almost invariably parallel with the mid-rib.

One peculiarity of the group, which you must often have noticed, is their tendency to form bulbs, or tubers. During its leafy stage, throughout the summer, the plant is busily engaged in sending down underground starch grains and proteids as a provision for the coming winter. Around the stem, at the base, thick, fleshy leaves are formed, containing nutriment for the plant next early spring, when food is hard to get from the soil, and the sunlight of the short days is scanty. By this means, for instance, the snowdrop is enabled to be up early and secure the necessary attention from insects before the competition grows keen. Notice, also, how these early flowers do not hasten the development of their leaves, which would find but little to do. When the common garden Crocus, for instance, has sent up its flower, until its work is done the energy of the plant is devoted almost entirely to it, but when the bees have carried away its yellow pollen,

and brought it what it needs from other flowers, the petals and sepals fade away, but the leaves now expand with redoubled vigour. The chlorophyll corpuscles multiply, and the factory is busily engaged in storing up reserves in the bulb.

There are, of course, far too many of the group for us even to mention all their names, but I want you to look a little more closely at some of the most typical and interesting, especially with regard to their methods of ensuring that the pollen goes to its proper destination, and is not wasted. All of the group seem to have a preference for pollen other than their own if they can get it, and usually secure this by ripening stamens and pistils at different times; but if they are not fertilised in the way they desire, it would seem that they are ready to accept their own pollen as a makeshift.

The Fritillary, or Snake's-head Lily, may be taken as an ordinary type of the way in which our present flowers are fertilised. The three sepals and three petals are set around the flower almost in one circle, slightly overlapping at the edges, and hang down, forming a bell over the stamens and pistil. (One may note again, by the way, the partiality of almost all these flowers for the number three. There are six sepals and petals—three of each; usually three, but sometimes six, stamens; and three carpels to form the pistil. This is a useful clue, if one finds a plant that one cannot at first

FRITILLARY.

place with certainty.) The Fritillary's perianth is chequered with mauve, pink, and purple, and bees fly to it, attracted by the colouring, and climb up the hanging bell for the honey, which is at the very top. Until the flower opens, however, the bud is boldly erect; but when the pollen would be exposed to the weather, the stem curves round, and the bell forms its protection. As the bee reaches the flower, he alights upon the top of the pistil, and leaves upon it, if it be ripe and sticky, some of the pollen from another flower. He pushes his way down to the honey, and, if the stamens be not ripe, nothing further happens; but if the stigma has been already fertilised, the flower employs his services in the reverse direction, for the anthers now dust him with their pollen for their friends. The fritillary also gives us an illustration of self-fertilisation, for, though the pistil ripens first, if it is not fertilised by bees, it remains sticky until its own anthers open and makes the best it can of a bad job with their help.

After this general type we may now take an exception, the Herb Paris. This plant seems to be rarer than formerly. At any rate, I have hunted in several places which it used to haunt without any success. Damp woods give the best chance of finding it, and it cannot well be overlooked, for it is like no other English plant, and at first sight not at all resembling a lily. An upright stem, crowned with a circle of large pointed leaves, spreading out flat, usually four in number, but sometimes five; and a spidery, greenish, purple-centred

HERB PARIS.

flower, with a purple seed-vessel in the centre, mark it out at once; and, to add to its peculiarity, it rejoices in a particularly unpleasant smell. The number three, for some extraordinary reason, is abandoned, and four is chosen as the key. Four long thin sepals and four yellowish petals surround, usually, eight stamens, with a four-fold pistil in the centre. Not content with all this eccentricity, the Herb Paris boasts of a network of veins in its green leaves, and refuses to abide by the ordinary parallel arrangement of its near relations. It does not produce honey, but Dung-flies appear to mistake it for carrion, and wander all over the flower, deluded by the smell, and, of course, bestow the pollen as the plant desires.

Another eccentric member is the Butcher's Broom, which declines to produce any leaves at all, or, rather, never brings them beyond an imperfect stage. In their place the stem is flattened out into a leaf-like appearance, as you will see from the illustration. On a young shoot the leaves can be seen as small scales, and from their junction with the stem the new branches spring forth, which flatten out and fill the leaf's office, the original scale-leaf humbly falling off. The flowers spring from the centre of these flattened stems, and the little scale-leaf appears again at the spot from which they come. Why the plant has taken this

BUTCHER'S BROOM.

course no one can say for certain, but it is suggested that the Butcher's Broom is especially anxious for moisture, which it cannot get in sufficient quantity on its favourite waste-ground habitats, and that the stems do not allow of so much evaporation as leaves would. Others say that it may be due to a desire to drive away browsing animals, and any one of these theories is possible, but none of them is proved.

The Iris flower deserves a close examination, for it can boast of an ingenious contrivance to ensure the services of bees, as well as the beauty of colour and shape that we noticed before. Looking at the illustration, which is of the large garden Iris, you will notice the two threes, the falling sepals and the erect petals. Towards the base of each sepal is a furry patch, which guides the welcome bee to the honey. Arching over the three sepals we see the three parts of a most elaborate stigma (pistil-top), beneath which are sheltered the three stamens. As the bee forces its way down, the pollen it has brought, or some part of it, is scraped off by the edge of the pistil's lip and from the anthers. If they are ripe it gets a fresh supply. The relative position of the pistil and stamens makes it almost certain that

IRIS GERMANICA.

IRIS.

Face page 136.

there will not be self-fertilisation, for the pollen cannot well climb up to the lip overhanging it.

The Orchids, or many of them, have adopted a most elaborate scheme to make sure of the carriers doing the work properly. Instead of casually dusting insects, they send out their pollen in masses, adjusted at a particular point, to the insects.

If we look at the general structure of the flower it will seem at first that all rule has been abandoned, and that they cannot be reduced to symmetry; but if you look a little more closely you will see that the three-fold arrangement has not been quite lost sight of. We may take as a type the broad-leaved Helleborine, an orchid with greenish-purple flowers, which I have found in woods in Wales. You will find a more elaborate description of it than I can afford space for here in Kerner and Oliver's *Natural History of Plants*, a book you should by all means borrow, and, if you can get it for your own, you are lucky.

You will see at once that the six parts of the perianth are present, the outer three more or less ordinary, but one of the inner three scooped out and swollen in a most extraordinary way. It is this one petal that is responsible for almost all the freakish appearance of the orchids, and if you follow the advice just given, and go to Kew, you will be amazed by its various transformations. Now a deep pocket, now like a bee, now like a spider, and now ribboned out into a crest, it takes twenty different shapes, each more fantastic than the last. The technical name

of this eccentric member is the *labellum*, or lip. Within the corolla is set a square column, into which stamens and pistil have combined. As a rule, in orchids two out of the three stamens never get so far as to produce pollen, and this is the case in our Helleborine, where two triangular points are just a reminder of an earlier stage. The third pollen-bearing stamen is close to one of the three stigmatic surfaces, which has also given up its ordinary duties of receiving pollen and sending down the tubes to the embryo seeds. This third stigma is modified into all kinds of shapes, but is generally beak-like, and is hence called the *rostellum*. The top of this rostellum becomes sticky, and touches the pollen masses of the anther, which promptly cling to it. One would think at first that the pollen-tubes might run straight down to their own seeds, but the orchid strongly objects to self-fertilisation, and so the rostellum does not *stimulate* any tubes, but simply holds on to the pollen, ready for a visitor.

A wasp, let us imagine, comes sauntering down the wood and scents the honey. He promptly settles on the labellum and begins to lick up the honey, which lies in the cup. As he raises his head, he knocks against the sticky top of the rostellum, to which the pollen masses are clinging on the other side. The wasp gives his head an unamiable wrench, and the sticky top, which comes easily away from its place, remains attached to his head, with the pollen masses sticking up in the air like a pair of horns. Off goes the wasp with his new head-dress, but it does not keep erect for long. After a little the weight of the pollen masses tilts them forward, and they swing down on to the front of the wasp's face, and sometimes over his eye, giving him a most rakish appearance.

Another helleborine comes in sight and he wants more honey; down goes his head into the cup, for he always begins at the bottom. He just touches the lower part of the column with his head and with his ornamental pollen masses. If the receptive part of the stigma is ripe and sticky, the pollen masses are torn away from the wasp, and if not they remain on his head for another flower. Moreover, if he lifts his head, he may have the luck to bag another brace from the rostellum at the top, and be able to fertilise several flowers, which he probably does before his day's work is over. All this sounds like a fairy tale, but it is sober truth, and is happening every day in summer-time in woods and meadows, wherever orchids grow, with slight modifications. I want you to notice how the two parties to the business both get profit from it. The insect could not live without honey, the plant could not start new prosperous generations without pollen from outside, and they both combine in the wonderful scheme of nature for mutual help.

I will close this chapter with a few hints where to find your orchids and how to distinguish the commoner sorts. For one or two, marshes must be sought, *e.g.* the Marsh Orchid, which bears spikes of rose-coloured flowers, with very long bracts, in June and July, and the tiny Bog Orchid, with a spike of minute greenish flowers. Chalk and limestone pastures are perhaps the most fertile soil of all, for there you will find the Early Purple in May with spotted leaves, and the Meadow Orchid with *green-veined* purple sepals. The Pyramidal Orchid is later, with a dense cluster of rose flowers with long spurs, and about the same time comes the commoner Spotted Orchid, with its cone of pale purple-veined flowers. The Butterfly you will find generally by the edge of a wood, with a

tall sweet-scented spike of large greenish-white flowers, and in the damper ditches comes the Twayblade, with small green spike and two egg-shaped opposite leaves on the stem. For the Bee and the Fly Orchids we must seek the drier pastures, and their names will identify them at once. For the Helleborines, with their loose spikes of greenish flowers, we must go right into the woods, and there too we must search for such rarities as the Bird's-nest Orchid, with no leaves and interlacing underground stems, and in the North for the Coral Root and the Ladies' Slipper, the spreading yellow flower and swollen lip of which are a great rarity for the plant-hunter.

CHAPTER XIV.

THE ELM, THE OAK, AND THE NETTLE

From this point to the end of the book, with the exception of the supplementary chapters upon special points in plant-life, on which this progression from the lowest forms to the highest has not enabled me to touch, we shall have to deal with the most highly organised group of all, the Dicotyledons, *i.e.* plants which form seeds within a seed-vessel, each seed having two seed-leaves.

In the great tests of classification, in method of growth and way of forming the next generation, they all stand on a level. Stamens and pollen, pistils with embryo seeds below, are to be found in every case, and if they live long enough each develops the cambium ring, and increases symmetrically in thickness in stem and branch, the "bundles" at their extremity branching out amongst the leaves in a network of veins, no longer restrained, as in the Monocotyledons, to parallel lines.

To this great group belong the very large majority of our English flowers, and all our native trees, except those that bear cones, which were dealt with in Chapter XI. As they are all practically at the same stage of development, although in one detail or another various individuals have made an advance, we can no

longer pursue our method of working up from the lower to the higher forms. It is as though we had come to the top form of a school, where all were on the whole of equal merit, but each has his special subject, classics, science, or mathematics. At the same time, we must have some rule of arrangement, if we would ever come to a definite knowledge, and the chief principle followed, within the actual borders of this group, is the form of the flower, and especially of those subordinate floral envelopes, which were called, as you will remember, the calyx, made up of sepals, and the corolla, of petals. Botanists, then, have made three divisions, first, those flowers which have either got rid of one of the envelopes, or have never developed more than one. These are called plants with a single garment, or *Monochlamydeæ*, and we shall have to deal with them in this chapter. Then come the flowers in which petals are "soldered" together at the base into a tube (*Gamopetalæ*), and these will be described in Chapters XV. and XVI. Last comes the group in which the petals of each flower's corolla are detached, these (*Polypetalæ*) occupy Chapters XVII.–XX. By-the-by, do not worry about trying to remember the technical names of these groups. They are not at all important, and it is quite enough if you can remember the simple principles upon which we are working.

In the first of these three groups, which only develop one ring of floral leaves around stamens and pistils, are to be found most of the trees in our woods and forests, but before we glance at them, we may examine a much humbler representative, with which everyone is painfully familiar, the common Stinging Nettle. Of this there are three kinds in England, all much alike in appearance, and needing no description, for they are almost the earliest

plants one learns to recognise and to avoid. Of one of the three, the Roman Nettle, Mr. Step, in his *Romance of Wild Flowers*, tells this delightful story. "According to legend, the Roman soldiers who occupied Britain were disgusted with the coldness of our climate, and took to flagellating themselves and each other with nettles to get up a circulation of their sluggish blood; but our nettles were considered too weak for the purpose, so they sent home for a more virulent variety, and we are invited to believe that the Roman Nettle was thus introduced to Britain"! No wonder they conquered the world.

To leave romance, however, and return to fact, there are three points of some interest about nettles. In the first place, they never seem to appear on unbroken soil, but have a strong preference for rich, good earth which has been recently worked. A nice new sheltered ditch, a neglected garden, or slightly decaying refuse, they find much more to their taste than competition in the open. In fact, it is said, though it is always rash to make so general a statement, that nettles are never found except where man has been at work upon the soil, and are a sure indication of his neighbourhood.

The second point, and one of very great interest, lies in their sting. Alone among our wild flowers the nettle possesses offensive weapons, for the ordinary thistle spike, or furze thorn, though uncomfortable to sit upon, does not inflict such vigorous punishment for the insult of a slight touch, although the nettle might perhaps plead that it has relatives which are much more terrible in their effects. There are nettle trees in the tropics which are positively disabling by their furious poison, and it is difficult to avoid them always when forcing one's way through the forest. A warning may here be given against a foreign

species of the Primrose tribe (*Primula obconica*), which is sometimes to be found in our greenhouses, and gives rise to a most irritating rash when handled by people with tender skins.

The Nettle follows the snake's example very closely, and injects a very similar poison. As one can see with the naked eye, it is covered with hairs, and under the microscope one sees that each hair has a very swollen base, in which the poison is stored by the cells beneath, which add that to their ordinary duty of starch-making. The hair tapers down towards the end, and does not end in a sharp point, but in a small knob. The wall of the hair is carefully strengthened throughout with a deposit of flint, so that it may have strength to pierce the skin of the assailant. When touched, the brittle knob at the top breaks off, and leaves a jagged point which promptly drives its way through, the pressure of the touch at the same time forcing up the poison, with unpleasant effects for the visitor, whether it be the incautious seeker after plants, caterpillars, or birds' eggs, or an inexperienced browsing animal, which probably decides after the first bite that the flavour of nettle tops is not worth a very sore mouth. One puzzle in the matter is that many caterpillars are quite indifferent to the stings, and find the leaves a very pleasant food, hairs and all. If you keep either Woolly Bear or Tortoise-shell caterpillars, you will see them crawling placidly at one time or another over all parts of the plant, although it is true that for feeding purposes they generally go to the under side of the leaf, where there are comparatively few stings.

STING OF NETTLE.

The third point is also one that you can see for yourselves, and with less discomfort, and that is the nettle's method of giving its pollen a good start in life. If you watch a nettle-bed in the early morning, at the time when the flowers are showing, you will notice that small clouds of dust spring from the clump when the sun's rays first strike it, sometimes seven or eight little spurts all together. This is the "assisted emigration" of the pollen. With only one sheltering ring, there would be an obvious danger that the pollen might get wet if the flower were open long after ripening, and the stamens have their pollen all ready and developed before the bud ever opens. If no sun comes, the four sepals — three was the key-number of the lilies and orchids; four and five are most common in this group—keep fast closed, the stamens coiled up within them, and their anthers shut. The sun comes, the bud flies opens with a snap, and at the same moment the stamens straighten themselves out, the anthers split, and the dust-like pollen is jerked into the air, and receives its fair chance of catching the wind and finding a ripe pistil-top ready for it.

There are some foreign connections of the nettle which deserve a word or two of notice, all the more because their relationship is not quite obvious. Two of the sweetest fruits come from this group, the Mulberry and the Fig, but no one who only knew them on the table would expect them here. The fruit is formed in a curious way in the Mulberry. The tassel of separate pistils, each within its calyx, grows into one body, as the calyx round each seed grows pulpy and juicy—an attractive morsel to birds, and a rich soil for the seeds within if it drops and decays. The Fig is an even more extraordinary fruit, for the flower-stalk is deeply hollowed at the top into a cup,

with a very narrow and barricaded entrance, and all the above flowers are *inside* the cup. There the fruit is formed, each little flower having its own seed-vessel, and the flower-stalk swells enormously, until the seed-vessels are almost close packed in the inside. As we know the fig (squeezed in a box), its shape has been lost, but the hard "seeds" within, as we call them, are really so many seed-vessels. Another fruit of this order, very famous in story, though, I believe, rather disappointing in reality, is the Bread Fruit tree of the South Sea Islands, of which one has had exalted, if vague, ideas from the day one was fortunate enough to read *The Coral Island* for the first time.

To return to our English plants, the Hop demands a moment's notice, for it is the only plant in the group that makes a regular practice of climbing up by supports, although the little Pellitory sometimes makes a weak attempt at it. It has not any special climbing apparatus, like the tendrils of the Vine, or the suckers of the Ivy, but secures its end simply by the constant twisting of the stem, which is rough and very strong. In its first stage it grows upright like a young nettle, but after it has got a few leaves the top part of the stem begins to swing round in a circle, seeking for some friendly help. In a hop garden it, of course, meets a pole put ready for it, but the wild one has to trust to fortune. Generally it is able to find a hedge, and twines round one of the branches. As the stem grows, the free end continues to wind round and round, the minor branches doing the same on their own account, until the hop gets to the top of the hedge, and wins thereby the valuable prize of an ample share of sunlight. Stamens and pistils are on separate flowers, and the former are arranged singly, whilst the pistils and seeds

have a close resemblance to a fir cone. As in that case, we find big overlapping bracts, with the flowers behind them, but the embryo seeds are no longer naked, and the seed-vessel would be enough to distinguish it at once, not to mention the leaves. It is, of course, these bracts which are used in brewing, and their value to the plants lies in their action as sails, when the seeds are ripe, and the wind comes to carry them far afield.

The same device of a sail is used by the Elm, the winged seed-vessels of which come down and carpet the ground in early spring, before the leaves have dared to venture forth; and, on a much smaller scale, by the Birch and the Alder. For the present, however, we need not go into details about forest trees, for they will deserve a supplementary chapter to themselves at the end of the book.

The *Spurges* are a very widespread, useful, and rather uninteresting family. As they are largely responsible for the production of India-rubber, or Caoutchouc, though some of the figs claim a share in the supply, the cyclist and electrician should certainly owe them gratitude, and perhaps the fact that they include the Castor Oil plant demands our respect, if not our liking; but from the point of view of beauty they do not rank high in England. The Dog's Mercury is a good example, and it has the merit of being the earliest of our common flowers to greet the spring, but its spikes of greenish flowers are not very attractive. The Petty Spurge and the Wood Spurge, with their red tinge on stem and foliage, are more attractive, but their flowers also are not very striking. These flowers are borne in spreading groups, and the stamens have no envelopes at all, whilst the pistils are content with a mere relic of them. Their

place is taken by a large, sheathing bract, which encloses the whole group and takes the place of a calyx. The most striking feature of the family is the milky juice which pours from them in such abundance when the stem is broken. It is this milky juice, of course, from which, in the larger foreign species, we get india-rubber.

In England, the spurges seem able to grow anywhere, on all kinds of soil, and in Asia and Africa they have been able to maintain themselves in waterless deserts, but have been obliged to modify their form. Leaves have been discarded as lending to evaporation, scales and hairs taking their place. The stems become thick and fleshy, in order to store up water whenever there is a chance, and the whole plant seems to take up artificial forms, the favourite being of the candelabrum type.

Another subdivision, which includes many of our wild flowers, we may call the Goose-foot and the Persicaria group. If in your rambles you find some single-garmented flower, with the flowers probably in a rather straggling spike, it is amongst this group that you must look for its name. Greenish red or greenish white are the usual colours, and waste grounds or roadsides the favourite haunts. The Dock and the Sorrel are good and well-known examples of the general type, but there is one that is really handsome, though its name is lamentably clumsy, and that is the Amphibious Persicaria. This may be found by, or in, almost any slow-running water, and bears a handsome spike of flesh-coloured flowers. Its cousin, the Buckwheat, largely grown as food for pheasants, has also some claims to beauty, and perhaps the Great Water Dock deserves our respect, for in olden days, before the Fens were drained, its leaves were the

food of the caterpillar of the now extinct large Copper Butterfly, and it may reflect that its ancestors supported a family whose members are now cheaply bought at £5 a head.

As for the Goose-foot clan, with their untidy leaves and green spikes of flowers, the most picturesque feature is the name, in addition to which one has the cheerful epithet of "Stinking," and, says one botanist solemnly, "is to be distinguished by its fishy smell, which is disgusting in the extreme," which always seemed to me rather hard on the fish. Another is called "Good King Henry," and I cannot find out why, nor which Henry has been selected, whether the victor of Agincourt or "the greatest widower that ever lived."

But we must pass on to two very different plants, which resemble one another in the flower but certainly in no other external detail—the Oak and the Mistletoe. We shall meet both again, amongst the forest trees and the parasitic plants, but here we may merely consider their flowers. The oak bears stamens and pistils separately, each in small catkins, and the pistil has at first three seeds within the ovary at the base. Only one of these, however, comes to maturity in each of the flowers, and it grows, as you know, to a very considerable size, a curious contrast to the tiny seed of the elm. The flower-stalk expands at the foot of the seed-vessels; the bracts and scales grow together; and the acorn cup is formed containing the one seed, or acorn, within it.

The Mistletoe, which, by-the-by, is very rare on the oak, though connected with it in story and legend, is a degenerate sort of plant, for it can only live at other plants' expense, although it provides part of its own living. The second whorl of floral leaves is not in

evidence now, although there would seem to be some trace of it still around the pistil flowers, which spring in threes from the ends of the branches, in the same fashion as the stamen flowers. The three female flowers produce three white berries, which ripen in the autumn and winter and are noteworthy for the great stickiness of their contents. This enables them to cling to the bark of trees to which they may be carried, and to hold on, in spite of wind and weather, until the young seed has had time to send out a rootlet and anchor itself firmly to the bark of its unwilling host.

CHAPTER XV.

DEAD-NETTLES, SPEEDWELLS, GENTIANS, AND PRIMROSES

In this and the succeeding chapters we find ourselves embarrassed with our over-richness, for we shall have to include in them many hundreds of different plants, each with its separate point of interest, but none of them so absolutely typical that in describing it we can give the characteristics of the whole group. The four that I have chosen to head the chapter will give a sufficient idea of the plentiful variety of beauty that lies before us here.

All these plants, however, and many others to which I shall have to allude in passing, are marked by certain points in the flower, which you should seek for in any new discovery, in order that you may at least know in what general direction to look for a knowledge of its complete history. You will remember that in the last chapter we had to deal with the group which contented itself with but one ring of leaves around the pistil and stamens, and that this ring was generally of a sober green. The rest of our flowering plants, with a few scattered exceptions, such as the Globe Flower, which we may disregard for the present, have developed and retain a double overcoat, our true calyx and corolla. In this

particular chapter we have only to deal with one section of these, namely, those in which the calyces and corollas are not built up merely of separate leaves, but are united at the base into tubes, one enfolding the other. At the same time, both in calyx and corolla, we find that the edge of the top of the tube, which usually expands into complicated shapes in the case of the corolla, is not regular and round, but divided into a varying number of *lobes* or sections, as one may see at once in the Common Primrose. Now, these lobes may indicate one of two things. They may be the reminder of a past, when the leaves composing calyx and corolla were all separate, though it has since been found more advantageous for the plant that they should combine, or, possibly, they may be an indication of the higher development, in which the sepals and petals are to become free from one another, as we shall see they are when we reach later tribes. On the whole, the former theory would seem to be a little more likely. Proceeding further in our subdivision, we find that these plants whose flowers are in one piece, so to speak, are divided into two smaller groups, those with the seed-vessel above the point at which these enveloping rings join the stalk, and those which keep their precious burden lower down. To the latter belong the Bell-flowers and the Daisies of the next chapter.

COROLLA OF PRIMROSE.

To give you an idea of how many of our favourite wild flowers are to be found in this group, let me give you a list of the chief "orders" which are ranked within

it. First come the Dead- (*i.e.* non-stinging) nettles; next the Plantains, in which cage-birds delight; then the Speedwells, with the Foxglove, Toadflax, and Mullein. The Toothworts and Butterworts come next, their interest lying not so much in their flowers as in their curious way of getting a living. Both we shall meet again, the first amongst the parasitic flowering plants, and the second amongst the insect-eaters; so we shall hear no more of them in this chapter, nor of the Dodder, which must also be placed in the interesting but rather unpleasant category of the parasites, which make other plants do their work for them. The Nightshade tribe cannot be omitted, for its importance comes home to anyone who either loves or hates tobacco; and the Borages, including the Forget-me-not, come close upon it. The Gentians come towards the close, followed by the Primroses and Pimpernels, and the list is completed by the Heaths, with their attendant Bilberries. Those of you who have begun your flower collecting will see how many of one's most pleasant captures are descendants of these noble families.

Let us look first at the very well-marked order of the dead-nettles, or, as they are known in Botany, the Labiates. This technical name is for once really useful, for if you remember that "*labium*" is the Latin word for *lip*, you will also call to mind the striking peculiarity of the flowers of this order. The corolla, mostly red in colour, sometimes blue, very rarely yellow, comes up from its base in a tube, and then, in place of expanding flatwise, the tube splits into two lips, giving the appearance of a gaping mouth (see illustration), the top part arching over the stamens like a helmet, the bottom forming an admirable platform on which insect visitors may rest,

when they call on the important business of fertilisation. It may be noted here that whereas the plants of the last group depended on the wind for the dispersal of their pollen, those we have now to deal with lay themselves out to attract insects, by striking flowers, sweet honey, and often by such savoury scent as delights even dull human beings in the case of the thyme. But not all insects are required. Small insects are not wanted, but above all bees and humble-bees are the favourites. One variety of the humble-bee, which has rather a short tongue, is kept away by the length of the tube from some of them; but, extraordinary as it sounds, he has found a way to revenge himself, and simply bites his way through the base of the tube to get at the honey, without paying for it in any way, by carrying off pollen to another waiting flower. In fact, he commits flat burglary. Everyone knows the white nettle, which comes up in ditches, hedgerows, and everywhere fairly early in spring, with its rings of white flowers around the stem, handsomely set off by its black stamens. In its leaf it greatly resembles the stinging nettle, and plenty of the genuine poisoner is generally close to it, so that the indiscriminating browsing cattle leave both respectfully alone; and even the rambling plant-hunter approaches with discretion at first, though he soon recognises that the teeth around the edge of the leaf are not quite so pointed in our harmless friend, and that the general texture is a good deal less harsh. No doubt this resemblance is of enormous use in protecting the youthful plant, but the eternal puzzle remains, "How has it come about?" If we suppose that in the struggle

LABIATE FLOWER.

for existence those plants had best chance in which the leaves were like the stinging nettle, and that such specimens of white nettle lived to produce other plants like themselves, and the tendency grew till the two leaves were almost identical, the question at once arises, "But why should this plant especially, of all those that grow in ditches, have adopted this sham stinging leaf, which would be just as useful to twenty more?" And we can only say that we don't know, but that if botanists go on steadily watching all they can, they may some day be able to explain both the White Nettle and the Nettle-leaved Bell-flower.

Up in the top of the helmet in the white nettle flower are arched the pistil and stamens, and the latter ripen first, so that their pollen shall not spoil the chance of the stigma being fertilised from some other flower. The bees, lighting on the lower lip as a platform, shake the base of the filaments, and the pollen is showered on their backs. They fly off with their feed of honey and go to another flower. Here the flower has perhaps been open longer, and you will find that the stamens have shed all their pollen, but the pistil has now begun to grow again and it puts forth a sticky top. The bee, diving down for honey, touches this stigma with his back, and the pollen dust is promptly taken up.

The Meadow Sage has a most ingenious device for ensuring that the bee shall get an ample load. The two anthers are set on a cross-bar, as it were, at the top of the short filament, one arm of which is much longer than the other. One anther is set on the short arm deep down in the tube, and the other, which alone bears pollen, is up in the helmet. When the bee thrusts his tongue against the anther which blocks his way to the food he

wants, he forces back the short arm of the lever, and the long arm brings the pollen-bearing anther smartly upon his back, to avoid any possibility of a bad shot. I cannot go here into all the various ingenious contrivances of the labiates to secure the proper deposition of pollen, but you will find elaborate details in Mr. Step's *Romance of Wild Flowers*, which I mentioned before. The Verbena, or Vervain, a rough-looking plant often found by the wayside, with tall straggling stems and spikes of small lilac flowers, is interesting as a plant that has come down in the world. In ancient times, Verbena was prominent at the worship of the gods of Rome; the priests wore chaplets made from it upon their foreheads, and bundles of it were used to sweep out the sacred temples. I believe that in England up to the Middle Ages brooms of Vervain were similarly employed, but I cannot tell you the exact evidence.

VERBENA.

The plantains we must pass by, and go at once to the beautiful Speedwell tribe which includes the Foxglove and the Mulleins. The perfect blue of the Germander Speedwell, or Bird's Eye, which lines the banks in May, picks it out at once, and we may examine it a little more closely, for it shows some interesting variations from the ordinary type of our chapter. The corolla is still all of one piece, but the "tube" is so short that it can hardly be called more than a ring. Instead of the usual five lobes, we have

now four of about equal size and the stamens are reduced from the usual four or five to two. The pistil ripens first, which is the less ordinary routine, and stretches out even before the bud opens, ready for a bee, or fly, to call after finding pollen on a yet earlier flower.

A second form is illustrated by the Foxglove, the handsomest, perhaps, of all the English Dicotyledons, with its tall spikes of purple or white bells, finely backed by rich red-brown rocks in a wood-side, or rioting in gay confusion over the prostrate form of some fallen giant of the forest. If we examine one of these spikes, we notice that the flowers ripen at the lowest first, and that the yet unopened buds at the top still point to the sky, whilst those beneath look wide-mouthed towards the ground. Three advantages are thereby gained. The buds, which have for the present no part in the business, stand well away from the flowers which have their work to do; the downward slope of those that are open protects the pollen from the rain; and it also makes them, probably, more convenient of access to the bees, for whom they have secreted their honey at the base. Notice, too, that all the fairy bells upon the spike are turned in one special direction, and that towards the open, supposing the plant to be on the hillside. They must hang towards any possible visitors, and leave nothing to chance. If you look inside one of the bells you will see that the lower part of the bell projects to form a platform, and then seems to guide the bee by a line of hairs to the honey at the top of the ascent. Close-set to the upper

FOXGLOVE.

half are the pistil and four quaint stamens, with fat, purse-like anthers of purple-spotted yellow. The pistil, if the anthers are still fat, will not be ripe, but if they have withered away, the stigma becomes more prominent, and exhibits a kind of mouth. The bee's back as he crawls up to the honey touches this stigma, and, if he has been previously charged, the flower's work is done. But the bee's is not, for, still anxious for more honey and pollen, he goes to the next flower on the spike. Here the fat anthers are just shedding their fruit. Part has fallen on the hairs of the platform, and all he can get of this the bee stores in the pollen baskets you may see at his knee-cap. But the shaking his ponderous head gives to the bell brings down fresh showers upon his back, ensuring that he shall earn the flower's hospitality. But suppose that the summer should be steadily and hopelessly wet, so that for several days together the bees stay at home. Such a supposition may seem difficult after such glorious summers as those of recent years, but the rain may soon pay us all back double. What will the Foxglove do then? Well, it is quite prepared for that also, for most of the plants of our present group, although they seem to think it better to have pollen from another plant, or rather, to exchange it, are still quite capable of fertilising themselves if they cannot do better. The anthers have usually a fair number of grains clinging to them, and if no bees have called, the hairy mat on the lower half will be packed with pollen. When the plant feels that the stigma has been ripe long enough, and can wait no longer for possible bees, the whole corolla loosens at the base, and slides down the style of the pistil, bearing its pollen along with it. Some of it is pretty sure to touch the stigma, and to

do all it can to fertilise the embryo seeds waiting for the pollen-tubes down below.

The Mulleins are handsome relatives also, much the same in fashion as the Foxglove, but with more downy leaves, and the yellow flowers are set round the spike on all sides, instead of on one only. So far as the "tube" is concerned, they follow the Speedwell example, and reduce it to a short ring. One curious feature about their spike of flowers, of which I can give you no explanation, is that the separate flowers do not seem to open by any ordered rule, but the buds first expand at any part of the spike, though generally about the middle. The Mulleins are peculiar among the Speedwell order for the development of all five perfect stamens. The Foxglove has only four, and the Germander Speedwell, in a fit of economy, has reduced them to two.

Besides the spreading flower of the Mullein and the open bell of the Foxglove, we have in this order the quaint Snapdragons and Toadflax, in which the mouth of the bell is shut by the expansion of the free ends of the lips. This preserves the pollen admirably from rain, and also from the visits of insects that might be content to take the honey, but whose shape did not make them useful for knocking the pollen from off the anthers. On the other hand the larger insects, such as bees, whose help they do require, can force their way down through the narrow slit.

I am sorry to say (for the Speedwells are a favourite tribe of mine) that several of the tribe do not live on their own resources entirely, but "convey" nourishment from the roots of other plants. They have a vigorous life of their own, green leaves and the usual chlorophyll machinery, but it has been proved that they prey upon

the roots of other plants, into which the sprouting seed sends its suckers. How far they depend upon such nutriment is not quite certain, and some of the accused have been reared apart from all other plants, but it must be confessed that they were very stunted specimens. Their chief British representatives are the Louseworts, Yellow Rattles, Cow-wheats, and the beautiful little Eyebright, which may be found plentifully on dry pastures where the grass is short. Upon these grass roots it makes itself an unwelcome guest, fastening tiny suckers upon them from its rootlets, and robbing them of the minerals they have been at such pains to collect and dissolve for the making of protoplasm. The Eyebright plant is attractive enough, shrubby in form, from three to six inches high, with many small, toothed leaves, and exquisite flowers, milk-white, veined with purple, and having a bright yellow spot in the middle, to guide the insects to its stores of honey. Upon the strength of its vigorous life in the air, apart from its doings underground, and the charitable suggestion of some learned botanists that, being an annual, at the end of the year it probably restores its living material to the host, by way of the plundered root, I have left it among the respectable plants, instead of relegating it to the "awful examples" of the chapter of Parasites.

The Convolvulus order I must leave, and hasten on to the *Solanaceæ*, or Nightshade tribe, a very important family in many ways, but not of deep interest botanically. But when you know that the underground stem of one is the Potato, the fruit of another the Tomato, the leaf of another Tobacco, you will agree that we could not leave them unmentioned. In England, however, we have not many species. The most striking is the Woody Night-

shade, which trails over our hedges, and hangs down its star-like violet flowers, set off by large yellow stamens, to be replaced in autumn by the graceful scarlet berries. This is sometimes called the Deadly Nightshade, but quite wrongly, for that is a very different and more

DEADLY NIGHTSHADE.

dangerous plant. Growing usually on ruins, a large-leaved, bushy plant, its single, dull purple flowers are unmistakable, as are also its berries, like large and solitary black currants, rich in a potent drug, belladonna. Except the toadstools that pretend to be mushrooms, no plant has a worse reputation for poisoning the unwary, and it is fortunate that it is comparatively rare. (I have only seen one specimen in casual plant-hunting.) The

Henbane is of the same order, and almost equally poisonous.

The Borage group is far more attractive in appearance, and here also we find, as in the Speedwells, that the flowers vary largely in the length of the tube, from a bell to a cup, and from that again to an almost flat disc. The bell-shape is well represented by the Viper's Bugloss, a rough, prickly plant which grows abundantly by the seaside, in old gravel pits or quarries and similar situations. At first the buds are a bright red, but as they open, as they do from the *top* of the cluster, the expanded flower turns blue, and it has been suggested that the contrast of the hues brings more insects to visit the plant. It is certain that all kinds of insects find it most attractive, and H. Müller recorded eighty different kinds that came to it for honey, a variety of agents that ought to ensure the pollen being properly placed by something. The bell type is followed by the Common Comfrey, which grows by the side of slow-running streams, and bears flowers which may be dirty white, dirty red, or dirty purple, but are always dirty. One curious fact I have noticed is that the purple and red flowers seem to require more nourishment, for they only seem to appear when the soil in which the Comfrey is growing is particularly rich in sewage or refuse of some organic kind. The richest colour I have ever seen was on a plant that was rooted by an astoundingly evil-smelling outfall from a paper-mill on the Cherwell.

A curious cup-shape is seen in the flowers of the Hound's Tongue, which grows chiefly in waste places near the sea. They are of a dull purple, and are also noticeable for the strong smell of mice, which they share with the whole plant. For its seeds, the Hound's Tongue

has adopted the barbed-hook device, and they stick like burs to the passer-by.

HOUND'S TONGUE.

The Common Borage itself prefers the flattened disc, and its star-like flowers, with their five bright blue rays and its dark purple stamens, are finely set off by the whitish-blue bristles that protect the plant from crawling intruders, such as slugs and snails, or from ants and such-like that might steal the honey without profit to the flower. The same disc, with a slightly longer tube, and less pointed lobes of the corolla, marks the Forget-me-nots, of which the best known is, of course, the Water Forget-me-not, with its bright blue disc and yellow central eye. Here is a point worth noting. Almost all the other plants of the order are close-set with prickles and bristles to protect them from devouring enemies, but the Water Forget-me-not is protected from these by the element in which it lives, and we find that the leaves are quite smooth and shining. Whether it used to have bristles, but dropped them when it found them unnecessary in the water, or whether it is that its brethren, formerly smooth water-plants, developed bristles when they started their life in a new fashion on dry land, is another of the puzzles to which several thousand future years of recorded observations may, perhaps, enable somebody to suggest an answer.

Of the Gentian group, your earliest-found example is almost sure to be the Centaury, its clusters of rose-coloured star-flowers brightening many of our roadsides;

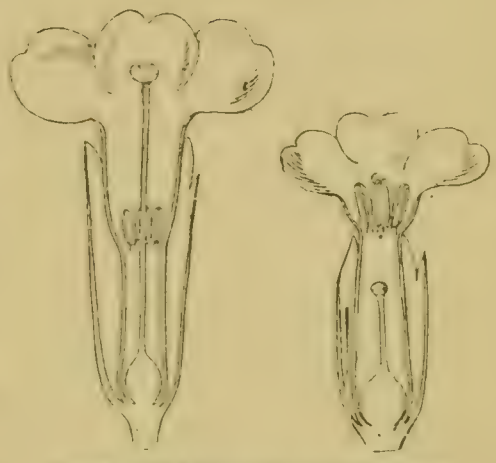
and on heaths you may often find the Field Gentian, with its dull violet flowers and deep tube, four-cleft at the top.

CENTAURY.

Two other Gentians are of such striking beauty that they deserve a mention. The Buck-bean, or Bog-bean, growing in soft marshes, is recognised in a moment by the three-fold leaf, from the sheath of which springs in early summer a long stalk, bearing at its summit a cluster of rose and white flowers, each delicately fringed upon the edge. A second, and rarer, beauty of the group is the Water Villarsia, which lives in a few slow-running streams, its round leaves floating like the Frog-bit's on the surface, and sending up at midsummer single flowers of a delicate yellow, the petals edged again by a fringe.

Primroses and cowslips need no general description, but they have a device to make sure of cross-fertilisation, which deserves a few words. If you examine several primroses, you will notice that the top of the tube is sometimes occupied by a knob, which is obviously the stigma, and sometimes by small pockets, which are equally obviously stamens. At first you may think that this is merely another case of keeping stamens and pistils on different plants; but if you open the flower, you will find that both stamens and pistils are always

present, but whichever is posted at the top of the tube, the other occupies a station half-way down! The tongue of a bee diving down a tube where the stamens are half-way up is dusted with pollen in the middle. When the honey is finished the insect rolls up its trunk, like the spring of a watch, and the pollen is folded with it. After going through the flowers of one plant it goes to another, which may happen to have the stamens at the top. When it thrusts down its tongue the latter unrolls and finds the pistil at the same point where stamens had dusted it before, and the pollen is now rubbed off its trunk.



TWO TYPES OF PRIMROSE FLOWER.

Meanwhile the bee's head has been all among the new anthers at the top of the tube, and at its next visit to a flower with a stigma showing, it will fertilise that in its turn. At the same time the pollen may also fall down from the top of the tube upon the stigma below, so that self-fertilisation is provided for if necessary.

The same need for self-fertilisation helps to explain the early-closing habits of the Pimpernel, for its stamens spread out far beyond the pistil, as a rule; but when the flower shuts, the petals knock off a little of the pollen and store it in the centre of the flower. When the corolla falls off it always chooses the time when it is closed, and so the pollen is dragged over the pistil, and if no friendly insect has done the work beforehand some seed will thus be formed.

The Water Violet, which has no connection with the true Violets, is a close ally of the Primroses, and if you

can gather it (which is not always easy, for it prefers the middle of the ditch), you will notice here also the double arrangement of pistil and stamen. The plant is unmistakable, with its finely-divided leaves and its tall, branching spike of white flowers, half an inch to three-quarters of an inch across. For the cheerful Moneywort, Creeping Jenny, or Herb Twopence, I can only spare space to note that in this country it is said never to form seeds, and to depend only on its creeping roots for extension.

The Heaths must in passing be noted, and also their strict adherence to the bell-shaped corolla. It is perhaps well to point out the difference between heath and heather, for the names are sometimes confused, though the plants are distinct. In the Heaths, of which two are common, we find large bells, perhaps an eighth of an inch across at the mouth, grouped in nodding clusters, and the leaves are undivided and set in circles round the stem. The heather, on the other hand, bears erect spikes of small flowers, and its leaves, which are very small, have abandoned the circular arrangement. Its flowers have an eccentric peculiarity in that the calyx, which is of a bright rose colour, overlaps the corolla tube, which is quite concealed within it. To aid this deception on the part of the calyx, four small green bracts are posted just at the base of the bell, and pretend to be the calyx themselves. It is not till one cuts the flower open, and finds the corolla within, that the true state of affairs is shown. Here, again, if you ask the reason, as I hope you may, I can only say that happily there are plenty of botanical puzzles still left for you to solve, and this is one of them.

CHAPTER XVI.

BELL-FLOWERS AND DAISIES

THIS, our second division of plants which have corollas in one piece, is distinguished by the fact that the seed-vessels are always *below* the point at which calyx and corolla join the flowering stalk. This is not a difference of principle, you will notice, but of a prominent detail, such as we must choose if we would establish any order in our imaginary school. The form is too big, and we must halve it in some way, even though all the members of it are on a level in their general work.

We shall not therefore be surprised to find, when now we have to pass from the Heaths to the Hairbells, that the resemblances are more striking than the differences. Very likely one may come across them side by side, the waxen pink of the Heath cluster set off by the nodding sky-blue bell that hangs in a graceful curve from the stalk, the slenderness of which gives the plant its name. The Hairbell has a long pistil which hangs down like a tongue in the bell, and makes an admirable resting-place for a bee. The stamens are lower in the bell, and close-pressed against the *style*, or pillar of the pistil, which is split for some distance down from the top. The two arms thus formed do not expand at first, but wait for the stamens to complete their work of shedding

pollen, which falls on the lower part of the style. There it is held by hairs, until some bee comes to force his way down to the honey, smearing himself with the pollen. In an older flower we shall find that the stamens have withered away and left the road clear to the nectar, but the pistil has now been roused to a sense of its duties, and the two arms spread out, barring the bee's way. Of course he soon pushes over them, but not before they have swept his body and obtained their due of pollen.

An interesting cousin of the Hairbell is the Nettle-leaved Bell-flower, which may be found in hedges and ditches, and which imitates the Stinging Nettle with even more skill than the White Dead-Nettle mentioned in the last chapter. It is every bit as harsh in texture, and the leaves are sharply toothed at the edge, but when you get quite familiar with both, you will notice that the leaves of our harmless blue-flowered friend are just a little narrower for their length. The flowers stand bolt upright, with wide-open mouths. And here is another puzzle. They seem calculated judiciously to catch all the rain and dew drops, to drown their pollen and dilute their honey, and yet they seem quite indifferent to the dangers against which other plants make such elaborate preparations. The leaves may serve to some extent as a shelter, but it can only be a very partial one.

The little Sheep's-bit Scabious, which is usually classed with the Bell-flowers, leads us on to the great order of the *Compositæ*, with its smaller allied order of the Teasels. We have seen that various plants, such as the Heaths, bear their flowers in a close cluster, and in the Compositæ this principle is carried to its extreme limits, so far that in common speech all of us speak of the 250 minute flowers which compose one head of the

Daisy as the flower, pure and simple. Yet a closer examination shows in a moment what has happened. The flowers have grown very small, the stalklets which connected them with the main stem have disappeared altogether, and they are now seated close together directly upon it. How many combine to form a group varies greatly. In the Yarrow, four or five combine to make one "flower," as we call it, but many of these fives are borne on short stalks very close together, so the idea of joint attractiveness is preserved. It would seem that these composite plants have been taught that the best way for them to multiply their descendants is to join their forces. Their tiny flowers, if separated, would never be seen; joined in their great masses, as for instance, in the Sunflower and the Dahlia, they are as striking as could be imagined, and may be expected to catch an insect's attention as quickly as the elaborate single flower of the orchid. Moreover, one important feature to note with the composites is that they are not wholly dependent on insects, and can use their own pollen just as well. If we are to judge by results, always rather likely to be a misleading test, their method would seem to be wholly admirable, for the Composites are by far the largest group in the flower world. Ten thousand individuals have already been identified and described, and the number is steadily growing. Moreover, they are as indifferent to climate as the English themselves, more so, in fact, for in every zone they not only exist, but multiply in

YARROW FLOWER.

numbers. We need not, therefore, be surprised when we find them very numerous in our British Flora; in fact, they are almost too numerous for the beginner in collecting, for there is no small difficulty in distinguishing the various species from one another. The thistles may pretty soon be mastered and distinguished, but the hawk-weeds are an abiding puzzle. There are many of them, all much alike, and to make matters worse, each species varies a good deal in habit, according to the soil; so questions of size are of no great help. However, they are well worth your patience, and careful comparison with the ordinary books of all the specimens you can find will soon put you at home with them. Remember especially that you need for identification some of the lower leaves as well as the flower-stalk and flower.

Before we examine the true composites I want you to look at two flowers which foreshadow their arrangement, the Teasel and the Scabious. Here we have close-crowded heads of many minute flowers, the separate flower-stalks having disappeared. In the Teasel, these flowers form a fine, purple, egg-shaped mass, several of which are usually borne upon a plant. The calyx of each floweret is quite small, and the sepals have been economised into bristles, whilst the heads are further protected by

TEASEL FLOWER.

small sharp bracts, which form a small sheath around each, the whole head having a corresponding array of bigger bracts about the base. The stamens first appear, and shed their pollen upon insects, and, when they have finished, the pistil begins to grow and projects its sticky top, so that it is sure to meet the bearers of pollen from younger flowers. The leaves also are of interest, for they spring from the stem in opposite pairs, their bases joining to form a cup around the main stem, in which rain and dew collect. One obvious purpose served by these cups is protection for the flower against crawling insects, for these climb up the stem, over the rim at the base of the leaves, and then tumble into the water. But the Teasel would seem to make a positive, as well as a negative, use of these fly-traps, for, as they decay, the flies, ants, etc., turn the water into a kind of soup, from which the plant is able to absorb much useful nourishment for itself.

The heads of the Scabious approach still more nearly to the Composite type, for they are almost flat, and a hint of the "rayed" formation that we shall notice in the daisy is given by the slightly larger size of the outer ring of flowerets. They do not, however, show the special characteristic of the genuine Compositæ, which are known by this peculiarity, in addition to those we have described, that the anthers are all joined together in a ring, thus forming a tube, through which the style of the pistil has to pass when it begins to grow.

Let us take as the type of the order, for a minuter inspection, the Ox-eye Daisy, or Marguerite, which one can find in almost any pasture throughout the summer, a good specimen measuring about $1\frac{1}{2}$ or even 2 inches across from tip to tip of the rays. At first glance, you would say that it is a flower with green, many-

sepalled calyx, a white, many-petalled corolla, and a yellow centre in which one presumes stamens and petals to lie. But all this is deceptive. That so-called calyx is really a row of bracts overlapping one another, and acting as a calyx for the entire group of flowers, in the same way as did the big single bract that enclosed the arum flower. Look also at our "corolla" under the glass, and you will see that each ray is itself a minute flower, with a tubular corolla, one lip of which has developed enormously into this strap-shaped ray. The effort of producing all this tissue in the corolla appears to exhaust the flower to a certain extent, for very few of these showy flowerets of the outer ring ever produce stamens or pollen, and some devote their whole energies to the corolla, and have not even a pistil. There is an exceptional group, which we shall meet later, in which all the flowerets are rayed, and all have both stamens and pistils. The Ox-eye is content with pistils in the white rays.

OX-EYE DAISY.

Now look at that yellow centre with the glass, and you will see that it consists of hundreds of little five-toothed tubes, each fully equipped with a ring of anthers at the top, and, if mature, there will also be in view a two-armed pistil spreading over each. This two-armed pistil does not force its way up until the anthers have shed their pollen, which covers the tube, like soot in a chimney; then the pistil forces its way up and sweeps all the pollen well out into the upper part of the flower. *After* that, it opens its two curling arms, and is at home to visitors.

CORN-MARIGOLD.

Face page 172.

This is the general type of composite flower, but there are two divergences. The ray-flowers may disappear altogether, as in the Thistles and in the Common Groundsel, leaving nothing but tubes, or the whole head may insist upon developing into ray-flowers, and then we get some of our loveliest composites. The sky-blue Chicory, the gay Dandelion, with its still handsomer cousin the Goat's Beard, and the Salsify, the purple heads of which are most often seen in kitchen gardens, all belong to this group.

This reminds me of a very interesting point in the domestication of plants. Our Ox-eye Daisy is a type of the original Chrysanthemum, but the object of cultivation has been artificially to increase the number of ray-florets, and to get rid of all the tubular ones. Richer soil and careful selection have gradually succeeded in doing this, but you will see the inevitable result. All the energy having gone into the corolla, the plant cannot also make stamens and pollen. The beauty of the plant is attained, but no seed can ever be formed by the pistils alone. All continuation of the plant to future generations must depend on cuttings. With the Dandelion and Chicory, on the other hand, the production of ray-flowers is an ordinary thing, and they have in each stamens and pistils, so that we need not fear that the Dandelion will become extinct and no longer invade our lawns, or that Chicory will ever fail to be sold as Coffee.

(I remember seeing once that a worthy tradesman of Wolverhampton was fined for selling coffee mixed with 95 per cent. of chicory, and I wondered of how many beautiful blue flowers that good man had robbed us. Dandelion roots are said to be used for the same purpose, but I should imagine that the trouble would be more

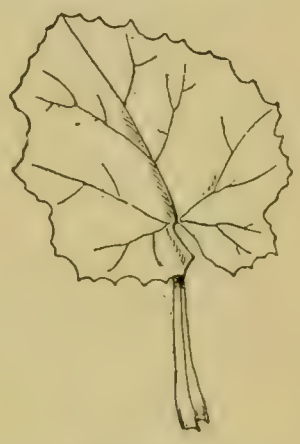
than they were worth. Like a good many other methods of adulteration in popular stories, this seems to labour under the objection that the genuine article is cheaper and less trouble.)

I must not leave the Dandelion without calling your attention again to its beautiful device for seed dispersion. The tiny bristling calyx, which takes the place of a ray of leaves, has here admirable use, for the bristles become, as you know, feathery and light, and are hoisted up by the growth of a long beak or snout at the end of the fruit. You must often have found a ripe dandelion head, and puffed them off on their adventurous journey, the heavy seed and the light balloon of the down combining to secure safe and steady transit. When the seed falls, the parachute action of the feathers keeps it point downwards, and at least gives it the best possible chance of safe planting in the kindly earth. Then, when it has reached a crevice, the wind that shakes the feathery plumes works the seed deeper and deeper in the soil.

The Coltsfoot is a member of the family which requires a special mention, for it is one of those plants that, in their haste to take advantage of the spring, send up their flowers at the earliest moment, without even waiting for the leaves to grow. One may find them in plenty on any clay soil, but I do not know why so many botanical books speak of wet fields as the chief habitat, for a railway cutting through the clay is dry enough, but they spring up there in the greatest numbers. In fact, it has always been a problem to me to explain their rapid appearance in such places. I have in mind one field at this moment where I had never seen a coltsfoot

COLTSFOOT FLOWER.

flower; but when a cutting was driven through it, the next spring saw the sides sprinkled with countless yellow heads. Had the seeds lain dormant for years down below? or were these all planted from the parachute seeds of other plants? The nearest I knew of were miles away, but that need not have made their voyage impossible. The heavy refuse of brickfields is also a site frequently chosen, and upon it, as one may well imagine, the coltsfoot seed is at least safe from too fierce a competition of other plants. When, after flowering, the plant sends up its leaves, they grow to a considerable size, six or eight inches across, and send down their reserve stores to the creeping root-stock. The Butter-bur, which groups its compound heads in thick club-shaped spikes (all of a dirty flesh-colour) is similar in habits, for its leaves come late, but they are of enormous size, sometimes spreading a yard across.



COLTSFOOT LEAF.

Of the Burdock, the seeds of which are carried far afield by the hooks on the involucre which encases them, and of the Carline Thistle, in which the bracts close right over the pollen when the air is damp and threatens danger, mention was made in earlier pages, and we must now leave the Compositæ, and just glance at two allied groups, represented by the Bedstraws and the Honeysuckles.

To the first belong the Dyer's Madder; the Goose-grass, the prickly twining stems and hooked pairs of seed-vessels of which you can find on every hedgerow; the Woodruff, with its whorl of leaves, its cluster of white flowers, and its scent of new-mown hay; and, a more

important plant to commerce, the Coffee Shrub, the large seed of which we know, inaccurately, as the Coffee Bean.

The Honeysuckle group includes the Elder and the Guelder Rose. The latter is very interesting in the arrangement of its flat clusters of flowers, for it lies between the Compositæ we have just left and the Parsley

HONEYSUCKLE.

type, to which we are now coming. The flowers have each a separate stalk, but they are massed in close heads, and those on the outer ring emulate the example of the ray florets of the Composites by growing their corolla to a much more conspicuous size than their brethren can boast, and thereby attracting insects more freely. You will remember that when the outer ring specialised in this way in the Compositæ, we found that they had no

energy to spare for making pollen, and in the Guelder Rose we find neither pistils nor stamens in these showy parts. Their work is simply to attract the fertilising insects to their working brethren.

The Honeysuckle itself needs no description, with its long, scented, tubular flowers, half-full of honey; but there are two points to which I would draw your attention. Though the tubes are quite separate, two of them often share a common calyx, and in many varieties two adjacent fruits grow together to form a single berry. The second peculiarity is that our English honeysuckle flowers twice in the year, in the early summer and then again in autumn.

CHAPTER XVII.

PARSLEYS, WILD ROSES, AND CLOVERS

In the next three chapters we shall give a rapid glance at all those English flowering plants which have free petals, or, where the corolla has disappeared, as in the Common Celandine, free sepals, no longer joined into a single tube, but each separable. Generally both sepals and petals are separate, but in many tribes the calyx is united, and you may consider this either as a sign of progress or not, according as you may decide that the tube-flower is a higher or lower state.

The first great class with which we have to deal is that which is well represented by the various wild Parsleys. If you have done any plant-hunting at all, you will need little description of the general type of the plants. The finely-divided leaves, the flat heads of many small flowers, usually white, sometimes yellow, each on a short stalk, the whole set of stalks meeting close below the flowering head, are in almost every case very well marked, and one can promptly decide that our novelty belongs to the *Umbelliferæ*, or umbrella-bearers. The worst of it is that, though the family is clearly enough marked out, this same general likeness makes it very hard to tell one species from another, and the young collector is rather liable to give up his task in disgust, and content

himself with a hasty decision that the thing is some kind of parsley, but what kind no sensible human being would waste his time in trying to discover. Now this is natural, but unwise, for half the pleasure of plant-hunting comes in at the end, when one wrestles with the botany books in order to identify one's captures. In two points we can generally find some clue to our search. Always notice carefully the arrangement of the bracts around the umbels (or clusters of flowers), and, if possible, examine the seed, for its formation and shape is often a great help. The seeds, also, have another interest, for many of them are traversed on the surface by small canals, which are full of oil, sometimes unpleasant, but more often aromatic. A good example is to be found in the caraway, growing wild in some parts of England, which one meets a good deal more frequently in seed-cakes.

It will not be possible here, however, to deal in detail with the many slight variations of the common type, so I propose to describe briefly some of the eccentric members, which one might not perhaps recognise for Umbelliferæ at the first glance. First comes a plant with a cheerful name, the "White-rot," which grows in marshy places, and is often accused by farmers of giving diseases to sheep, though as a matter of fact the guilty party is an unpleasant animal parasite called the "fluke," which the sheep picks up when grazing in marshy places, only to find that it takes up permanent residence as an unwelcome guest in its liver. Our present retiring friend creeps about low down in the herbage, and is most easily recognised by the round leaves, which are supported by a stalk in the centre, like the leaves of the garden Nasturtium. The reddish-white flowers are in very

small clusters underneath the leaves, and need some finding.

A pleasant contrast to this maligned and insignificant flower is given by our next example, the Sea Holly, which at first sight does not seem to belong to this order at all, but rather to hanker after the thistle group. The flowers are blue, alone in the order, and the stalks have almost disappeared, crowding the head very closely together; but if you examine the flowers carefully, you will find that the petals are not in a tube, and that they really have a short stalk. The leaves have also followed the thistle pattern, and are extremely prickly. The favourite home of the plant is the sandiest part of the sea-shore, of course above high-water mark, for it does not care to be soaked, and one is puzzled at first to think how it can get a living in such an arid situation. You will find a partial explanation if you try to dig up the plant, roots and all, for you will find these roots driving down and down, sometimes for several feet, to gather up every scrap of moisture in the neighbourhood. Moreover, when the moisture is obtained, the roots do not send it all up to the leaves, where the sun's heat might make it evaporate, but store it up in their fleshy cellars beneath the surface.

SEA HOLLY.

A third eccentricity is the common Thorow-wax, or Hare's Ear, which you may find on cornfields where the soil is very dry, usually on gravel or chalk. We have not only abnormal flowers, but also a new kind of leaf,

for the main stem passes right through them, or, if you would put it another way, they grow completely round the stem. Moreover, the stem does not choose the centre, but a point near the large end. As for the flowers, they are put in the shade by large greenish-yellow bracts, which envelop each section of the umbel like a cup, and make the tiny yellow flowers in the centre look like so many stamens.

HARE'S EAR.

The Samphire is of interest, for where it lines the cliffs one can know at once the high-water mark of the sea. Down to that point, or near it, it will creep, but not below. It has an ordinary yellow umbel, but its leaves are of an unusual kind for its family, thick, fleshy, and unbroken at their edge. Now the problem the plant has to face is just the same as that which the Sea Holly solved by its long, thick roots, namely, how to keep sufficient moisture in the face of the burning sun which falls full upon it, unshaded by other friendly vegetation. The Sea Holly had an easy task in driving roots through the sand, but it would be a very different matter to send them into a solid cliff-face. The Samphire, therefore, adopts perforce the cellarage system in its leaves, for you will see at once that the thicker they are the more slowly will the water get away, just as a rolled-up towel would keep moist for hours after one that had been spread out in the sun was perfectly dry.

There we must leave the Umbelliferæ, and before we

come to the Roses we ought to glance at one or two of the flowers that lie on our way from one to the other. First let us take the White Byrony, which you may see sprawling in somewhat parasitic fashion over our hedge-rows. Greenish-white flowers, about half an inch across, bearing either stamens or pistils, but not both, give rise in the latter to handsome red berries in the autumn, which are emphatically *not* edible. It deserves notice, not so much for its own importance as because it is our only British representative of the great Gourd tribe, to which belong all the pumpkins, melons, marrows, and cucumbers, and of one of these, the squirting cucumber, it is worth while to give some account, for its ingenious method of spreading its seeds. The fruit, which is like a small cucumber, hangs down the stalk, which projects into it and plugs it as a cork plugs a bottle, and keeps the seeds safe from harm till they are ripe. While they are ripening the cells in the rind are filled with fluid until they ardently desire to stretch, but, of course, the plug forbids it, for the bottle is full. The pressure goes on, and in time all the interior of the cucumber, except the seeds, turns to jelly. The plugs begin to do the same, and some morning the cucumber drops off, and the cork is gone. Now the cells in the rind have their chance, and they swell at once most vigorously, forcing jelly and seeds through the neck of the bottle in just the same way as one can squirt water by pressure from an india-rubber ball.

A nearer approach to the Roses is made by the Willow Herbs, of which the Evening Primrose is perhaps the best known, though it is rarely found wild. Its large, pale-yellow, fragrant flowers only open in the evening, in contrast to the ordinary practice, but the reason is

WILD ROSE.

Face page 182.

that it depends upon moths to fertilise it. An interesting point in its opening is the extraordinary rapidity with which the petals unroll. In one half-minute the flower passes from a close-folded bud to the full-blown stage, and if it is fertilised by a moth that evening it rolls up promptly, and never opens again. The moth thrusts its trunk down the long, tubular corolla for the honey, and dusts its head with the pollen, and at the next flower it is pretty sure to touch the cross into which the stigma divides. Its cousin, the Hairy Willow Herb, ornaments most of our ditches with its tall, downy stems and its bright heads of rose-coloured flowers. Near to it we may also find the purple Loosestrife, which appears in *Hamlet* as the "long purples" or "dead men's fingers" upon the banks of the stream in which lay drowned Ophelia.

EVENING PRIMROSE.

If a ballot were taken for the most popular and best-liked class of English wild flowers I think that the Rose tribe would probably come out at the top, though closely followed by the Compositæ with their overwhelming numbers. The Compositæ would be handicapped by some rather ugly members of the family, which it would be impossible to keep out of sight, but the Rose family would not have a single skeleton in their cupboard. The

Lady's Mantles are, perhaps, the poorest in flowers, but they win their way back to favour by their graceful growth and handsome leaves. As a rule the flowers are fairly large for the size of the plant, and brightly coloured with white, pink, or yellow. Blue is entirely absent, and, as you may know, the garden rose, in spite of all the efforts of growers, refuses to produce a blue specimen for any known means of persuasion.

The general type of flower has five sepals, five brightly coloured petals, a large number of stamens, and a large number of pistils. The yellow is peculiarly clear, and free from the orange tinge of the buttercup; it is in fact, or ought to be, your perfect yellow, which Bottom demanded in the *Midsummer Night's Dream*. Nowhere have we a better example than in the well-known Silver Weed of the roadside, the grey silky leaves of which show up to perfection the lemon of the flower, in spite of the dust in the midst of which it thrives. Near to it one finds the creeping Potentilla, with rather darker, but equally clear, flowers; the hedge is snowed under with the May, and the fields near fragrant and bright with the Meadow Sweet, all kinsfolk of the Rose. The May flowers may still be lingering when the Wild Roses appear, and their hips and haws together brighten the winter hedges. In the earliest spring the Blackthorn faces the threatening snow shower with a pale imitation, and in a little while the orchards are a mass of white with plum and cherry blossom, the almond preceding them with its rich pink bloom, and the apple tree combining both tints in equal harmony. In the autumn the changing foliage of the tree is once more set off by the scarlet of the apple or the violet of the sloe. Nor would they be forced to rest their claims on beauty alone.

Just imagine how our meals would be modified if the fruits of the rose tribe disappeared. Gooseberries and currants would remain outside the pale, and so would grapes, but apples, pears, cherries, plums, raspberries, blackberries, etc., would be swept away, and we should find it very hard to replace them. However, there is certainly no present sign of disappearance. In fact, it is much more likely that their use will increase, for we may reasonably hope that before long the blackberry will be brought under careful cultivation, and show as striking a development as the tiny strawberry of the woods.

Beautiful and useful as they are, they do not display many striking features from the botanical point of view. As a family, they have few eccentricities. The pretty little Tormentil, for some reason or other, has dispensed with the fifth petal, and bears a bright yellow cross, but has the typical Potentilla leaf and a large number of stamens, so that there is no fear of mistaking it for one of the Crucifers, which we shall soon have to discuss. The only other striking deviation from family type is the case of the Lady's Mantles and the Burnets, which make no effort to attract insects by conspicuous flowers, and have dropped the corolla altogether. The commonest of these is the Salad Burnet, the flowers of which we will consider more closely. They grow in a clustered knob, and look something like a Ribwort Plantain, but

TORMENTIL.

the leaves will show the difference at once. When they open, you will see that in the upper flowers of the bunch are the pistils with crimson, tufted heads, and in the lower are many stamens with long filaments, which hang like tassels far outside the flower, and produce abundance of pollen. As one would expect from such an arrangement, insects are not the agents to carry the pollen forth, but the wind, and for this method the tufted heads of the pistils are admirably adapted, for any pollen blown to them is caught and held. One may note also that the pollen is kept *beneath* its own pistils, which would show that the plant has a preference for cross-fertilisation.

SALAD BURNET.

The Rose tribe is fairly well marked, but is nothing like so considerate to the botanist who wants definite grouping as the third chief division of our chapter, the Pea and Bean, or Clover tribe. These all have a most marked and peculiar formation of the petals, and though the flowers may be solitary and large, or small and clustered, there is never any doubt, amongst our English flowers, where they must be placed. The ordinary Sweet-pea of the gardens shows the arrangement very well, and if you consult the illustration, or, better still, a living example, you will realise its ingenuity. One petal is very much larger than the rest, and stands well back from them when the flower is expanded, though when in bud it tenderly wraps them all round. This is known

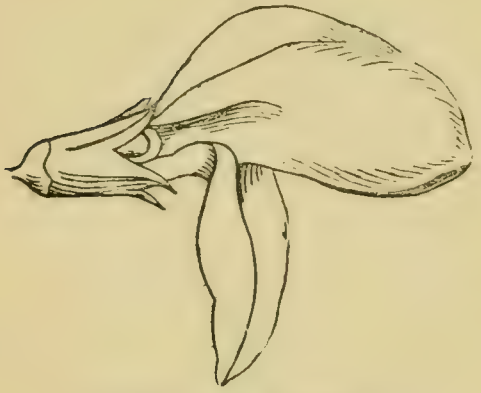
as the *standard*. The other four petals are combined in two pairs, forming the *wings* and the *keel*. The wings spread out sideways at a greater or less angle, and the keel, formed by the last two petals, projects in front, and conceals within it the stamens, ten in number, nine united in a tube, and the pistil. The wings and keel interlock at the base, so that pressure on the former tends to depress the keel and expose the stamens. Almost all prefer to be fertilised from other flowers, though they can, if no insect comes, use their own pollen. Clovers are visited chiefly by bees, butterflies, and moths, a fact worth remembering if you are a hunter of insects as well as of plants; and the two pursuits go very well side by side.

SWEET-PEA.

We have only space to notice one of the family in any detail, and I will choose one of the most frequent, "The Common Bird's-foot Trefoil." Very likely you do not know it under that name, for that is but one of its titles. I have known it called Butter and Eggs, Eggs and Bacon, and, though this I have only found in books, "Shoes and Stockings." The two colours, yellow and brown, may have suggested the first two names, for a lively imagination might recall a favourite breakfast dish; but why "shoes and stockings"? I give it up as a

hopeless problem. If any of my readers, by-the-by, can solve this or any other of my puzzles, or have others still of their own, I should be delighted to hear from them, and, when I can, explain the difficulty or add it to the many things I want to find out myself.

The drawing of the flower will probably bring it to mind, if you do not know the name, and we will now see what happens when a bee comes to visit it. Remember that the stamens are all crowded together in the boat-shaped pair of petals, with the pistil in the middle. As they shed their pollen, it is all stored up in front of them, in the bows, so to speak, and they are coiled up behind it. A bee comes and lights on the wings, and his weight presses them downwards and apart. But the wings, as you may remember, interlock with the keel, which is thus forced downward as well, and frees the stamens from control; they straighten out, and force some of the pollen in the bows of the boat right on to the bee sitting above. When the bee goes the keel springs up, and the stamens either go back again or curl away backwards, if they have finished shedding pollen, out of the way of the pistil. This pumping performance may happen several times, but when the pollen is cleared out of the way, and the bows clear, the pistil begins to grow, and the next time a bee sits on the wings the old leverage action allows the pistil to touch the body of the bee, and to have a chance of finding some other flower's pollen upon it.



BIRD'S-FOOT TREFOIL.

There is another point of great interest in the Bird's-

foot Trefoil, connected not with its flower, but with its roots. If you pull up a plant from the ground, you will find little galls, or tubercles, attached to the roots, and you would find the same in a large number of members of the family. Now, at first, people thought these were simply a symptom of disease, and this idea was thought to be strengthened when it was found that these tubercles simply swarmed with colonies of some kind of those small funguses which you were told of in Chapter VII., and which are called "Bacteria." But more careful examination tends to show that these are among the useful bacteria, "paying guests" in fact, and that it is a case of partnership, such as we saw among the lichens. It has been known for some time that many of the clover tribe got more nitrogenous compounds from the soil than seemed possible, and it has been suggested, with great possibility of truth, that these bacteria can do what the bigger plant cannot, and that is, take up the nitrogen of the air and work it up into suitable food material! It cannot be said that this is proved as yet, but it is probable, and suggests still wider possibilities of co-operation in nature.

The Stonecrops, to which belong almost all our English plants with fleshy leaves, we must pass by, only remarking that the flowers of most of them recall small, starry potentillas, which, with the leaf-structure, identifies them at once. The Wall-Pennywort has leaves stalked like the White-rot and spikes of greenish-yellow flowers, and is common enough in the West of England. The Saxifrages must also be left on one side, with the reminder that the London Pride of our gardens has fairly typical flowers, or, better still, the beautiful Meadow Saxifrage, with its pure white flowers and bulbous tubers at the roots, like small potatoes.

CHAPTER XVIII.

GERANIUMS, WOOD-SORREL, AND CAMPIONS

If you pass through a wood in winter, when all the leaves have fallen, you will probably have your attention drawn to a shrub which you passed by in the wealth of summer foliage, and will see a gleam of red berries, pinkish, not scarlet, like the hawthorn berries. A closer look will show you some seed-vessels of curious shape, in from three to five divisions, and where the walls of the seed-vessel have split you may see within a bright orange-coloured fruit. This is the Spindle Tree, which earlier in the year bore small greenish-white flowers, usually with four petals each. That orange, fleshy rind encloses the seed, and one may conjecture fairly that the bright colours are to attract the birds, which will probably drop on the ground quite as many seeds as they eat; and even if the seeds are actually swallowed they are so hard that they may defy the bird's digestive powers, and, after an adventurous course in its interior, resume a free exist-

SPINDLE-TREE FRUIT.

ence miles away from their original home. Closely allied to this are the various grape-vines, which probably came from the East originally and are now cultivated in endless variety, both for their fresh fruit and for many kinds of wine. (Various police prosecutions warn us not to imagine that they are responsible for all. The homely and useful gooseberry and the cider-apple have a very large, though unacknowledged, share in much of the "champagne" that is sold, whilst in the very cheap clarets and ports one would often find that the only constituent which can claim legitimate descent from fruit is the spirit with which they are doctored, and even then there are dark rumours of sawdust and still less appetising ingredients.)

Another vine of great beauty, though not of any particular use, is the well-known Virginian Creeper, and its habits of growth would at once suggest the relationship, even apart from the similarity of the flowers. As it is not a native we must leave it with respectful admiration and pass to a large and common group of English wild flowers, the Geraniums, of which there are about twenty varieties, including the Stork's-bills. A common term for the family, by-the-by, is the Crane's-bills, which is given to them on account of their long-beaked seed-vessels. All our English examples bear flowers of red or purple. That is to say, the base colour appears to be red, but in almost all there is some admixture of blue, which in the Dusky Crane's-bill reaches such a pitch that the flower is darkened to a dinginess almost black. In the Meadow Crane's-bill the result of the mixture is a purple, in which the blue has rather the better of it, with the effect of making a charming flower; and in Herb Robert, which is to be found in every ditch, the red

wins easily, although, as you would discover if you tried to paint an imitation, there is still some blue in the mixture. We have thus a variety of clues which help us to assign a plant to the order. Purple flowers, the red having generally the better of it, long pointed seed-vessels, calyx and corolla each in five separate pieces, combine to make us suspicious. When, in addition, we find the plant downy or hairy, our suspicions become almost certainty, for all but one of our present order share this peculiarity. The leaves give a less certain clue, for some have almost entire leaves wrinkled at the edges like the ordinary geranium of the garden, whilst most have them deeply divided, like the musk geranium of the greenhouse.

The Stork's-bills have long been famous for their seeds, which are used as instruments for testing the dampness of the air. When they are ripe they first become freed from the seed-vessel at the base, and they gradually peel away a strip of the long, thin structure, working up to the top. This strip steadily curls itself up, corkscrew fashion, for over half its length, leaving the last part straight, pointing away, usually at right angles to the general direction of the screw. When the whole falls away the seed, as the heaviest end, naturally gets to the ground first, and, being itself provided with barbs pointing upwards, is difficult to move. Suddenly some moisture falls on the corkscrew, which at once tries

STORK'S-BILL SEEDS.

to push itself straight out. But here the projecting arm at right angles gets in the way, for it has probably either caught in a crack in the soil, or is blocked by some herb. So the pressure tends to force the other end, the seed end, away, and this is well suited to move, for it has a boring point. When the corkscrew gets dry again it finds the seed hard to draw back, because of the barbs on it, and the arm has to give way and draw a little nearer. Thus in time the seed gets buried, and the curled beak above, its duty satisfactorily accomplished, dies away.

In Chapter V. we talked of the rather different method adopted by the Wood-sorrel and Balsam to give their seeds a good start, and you may remember that they preferred the explosive method, somewhat after the fashion of the Squirting Cucumber. As the Wood-sorrel is a close relative of the Geraniums and has another point of interest, I will describe it here. As its name implies, we must look for it in woods and damp, shady places, and there we may hope to find the delicate trefoil leaf, pleasantly acid to the taste, darker below than above, and in May or June the exquisite white flowers, marked with the purple veins which guide the insects to the honey. If you tap the leaf-stalks, you will find that the leaflets promptly shut down, as they do every night when the sun goes down. Remember that a plant has no muscles like ours, and this prompt action of the cells becomes in view of this astonishing. Many suppose this to have been the original Shamrock which St. Patrick used to illustrate his sermon to the

WOOD-SORREL.

Irish, and it has certainly as good a claim as any other plant, which is not perhaps saying very much after all.

The sweet-scented Lime-flower, with the eternal "murmur of innumerable bees" around it, stands at the head of the third series of our many-petalled flowering plants, known botanically as *Thalamiflorœ*. If you happen to remember the name, well and good, but if you do not it does not matter, for, as I said before, this classification of flowering plants is based upon differences of detail rather than principle, and perhaps before very long some other system may be adopted. We shall meet the Lime again in the chapter on forest trees, and for the present I only want to call your attention to the bract which clings to the flower-stalk, and comes twirling away with the seeds when they are ripe, leading them away from the overwhelming shade of the parent.

Equally familiar with the Lime, or even more so, is the Mallow. Everyone knows the dusty, roundish leaves, from amongst which spring the spreading rose-coloured flowers. The Mallow is no retiring or delicate plant, but in every hedgerow, by the roadside, and on waste ground, it springs up cheerfully and vigorously, defying dust and drought. Almost as early a recollection as the flower is the seed-vessel, the Mallow "cheese" which most of us have eaten, and found it at least harmless, though only enjoyable from the pleasant childish sense of bold adventure in the essay. They might have had a further interest, if one had known then that the cotton plant is a close ally of the Mallow, and that the hairs from which calico is woven are the beautiful covering of the cotton-seed, not so edible as the "cheeses," but of infinite importance, not only to the millions of Lancashire work-

HAIRY ST. JOHN'S WORT.

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men, of whose industry it is the raw material, but to the far wider populations of the tropics which depend upon it, almost wholly, for their clothing.

Next come the St. John's Worts, of which in England we have thirteen examples. Although you may have some difficulty in deciding which is which of them, there is very little labour required to assign them to their group. The flowers are always yellow, rather of the conventional star pattern, and usually grouped in heads. The plants themselves are usually somewhat stiff and rigid, and many of them are marked by clear transparent dots in the leaves, the result of large oil-glands, which barely intercept the light. The Large-flowered St. John's Wort is rather an exception. The flowers, about one and a half inches across, are solitary, the leaves large and glossy. It may be often found in gardens and shrubberies, and occasionally wild, bearing in some parts of the country the name of "Rose of Sharon." The petals and sepals keep strictly to the typical five.

A large and handsome group is composed by the Campion family, whose ornamental members one meets in gardens as Pinks, Carnations, and Sweet Williams. At the other end of the scale of their magnificence come the tiny Chickweeds, or Stitchworts, the handsomest representative being the Stellaria, or Greater Stitchwort. This plant we may thank for the graceful white flowers that adorn the ditches in spring, with their fine-cut petals and modest, bending heads.

STELLARIA.

The Chickweed group, so far as we

know, depends almost wholly on self-fertilisation, but the campions draw moths and bees to them by their bold and handsome flowers. I have not space to do more than allude to some of the commonest. The pink campion is generally to be found setting off the bluebell's colour on shady banks in May, though, being of hardy nature, it will often wander forth to the roadsides. In drier ground, and a month or two later, lifting its purple top amongst the corn, one may find the Corn Cockle. Whether it be due to more careful weeding of the crops I do not know, but it is certainly my own experience that this beautiful flower has become much rarer in the last ten years, and I count it now amongst the successes of an afternoon.

To find the Ragged Robin, which gets its name from the deep-cut segments of its red petals, we must reverse the process, and go off to marshy ground. Once found, there is no chance of its being mistaken for any other English plant, for its petals at the first glance look as if they had been snipped about with scissors, and remind one of an early yellow crocus which has had the misfortune to annoy the dignity of a sparrow, and has been pecked to pieces as a punishment. The Bladder Campion is known at once by its heads of white flowers, and by the inflated calyx from which it gets its English name. There is a curious copartnership of this flower with one of the Noctuæ moths. The moth does the work of fertilising it, and in return the caterpillar employs the bladder-like calyx as its daily resting-place, and the mutual advantage is thus secured.

Both Campions and Chickweeds abide by the regular number five for sepals and petals, but in the former the sepals combine into a single tube at the base, only

indicating their original number by the five separate points at the top of the tube.

Our last example in this chapter must be a very pretty wild flower, called the Milkwort. Go to any chalk-down or fairly dry pasture, and you ought to find a small plant, from two to six inches high, a miniature shrub, with an abundance of small flowers ($\frac{1}{4}$ to $\frac{5}{8}$ inch across), that remind one somewhat of the pea and bean tribe. As to their colour, I have found them dark blue, light and dark red, mauve, and pure white, so you will see they are not afraid of variety. You will remember the five petals of the pea—the standard, the two wings, and the two that formed the heel. Well, for some reason this is closely imitated by the Milkwort, but with quite different parts. Two of the five sepals become enlarged, and stand out at right angles to the main flower, putting on a bright colour, like the corolla. This corolla has only three petals, but *one* of them, not two, forms itself into a boat-shape, in which lie the stamens ready for employment.

CHAPTER XIX.

POPPIES, CRESSES, VIOLETS, AND BUTTERCUPS

The first two groups we have to take in this, the last chapter on the Dicotyledons, are marked by one feature which is a constant help to their identification. The flowers are symmetrical, that is to say, each sepal and petal conforms to the ordinary type, and we have no long spurs or keels to mark out any one petal in particular, and they have a set determination in favour of even numbers. The poppies have two sepals, four petals, and an even number of stamens, but the cresses are still more consistent, and easily assigned to their proper group, for they always have four sepals, four petals, and four stamens of the same size. The symmetry is only marred by an additional pair of longer stamens, which brings the number up to six, and most botanists maintain that these two are the sole surviving descendants of a second group of four. The only plants that can be possibly confused are the Bedstraws, and that only for a moment, for in their case the petals form a *tube*, whereas in the Poppies and Cresses, or Crucifers (cross-bearers), each petal is separate to the base.

The Poppies need little description, for they are as well known as daisies, both by their flowers and by the

POPPY, CORNFLOWER, BARLEY.

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milky juice which flows from their broken stems, one of the family being responsible for all the good and evil done by opium. Two, perhaps, require a special mention, the Yellow-horned Poppy and the Greater Celandine. The first is a lover of the sea-shore, where its glaucous, grey-green leaves and its spreading yellow flowers make it conspicuous in the summer. Its most eccentric feature is the enormous length of the seed-vessel, which begins to lengthen as soon as the corolla falls away, and pushes on and on until it reaches sometimes to eight or ten inches, looking like a leafless stem.

The Greater Celandine is another example of the confusing character of our popular names, for it is not at all a close relation of the well-known Lesser Celandine (which is a Buttercup), but is a true Poppy. Old cottage walls are a very favourite spot on which to look for it, and it cannot be mistaken, for its deeply-cut leaves and its four yellow petals, with the pistil rising high in the middle, rouse suspicion at once, which is confirmed by the orange juice that pours from it when plucked.

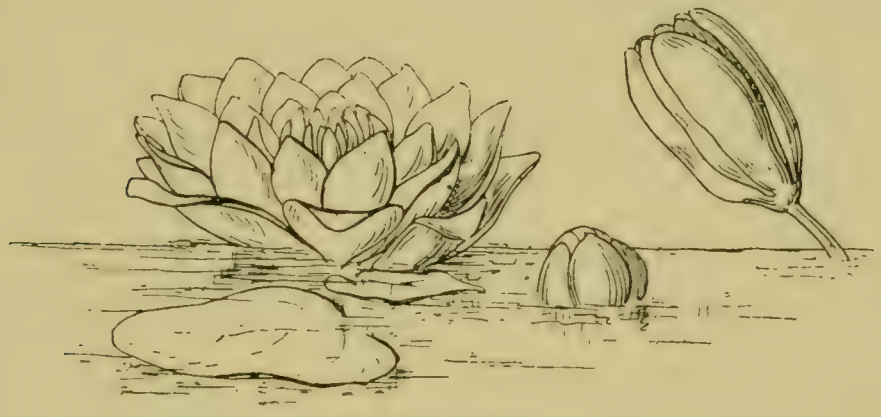
GREATER CELANDINE.

The very large cress family is noteworthy for its lack of handsome flowers, in spite of the number of its species, for most of them fertilise themselves, and, not needing to advertise their presence to insects, are content

with small white or yellow flowers, such as we find on the Shepherd's Purse, or on the Hedge Mustard. But it would be ungrateful to forget one or two which help to make the country beautiful, or to despise the eminently useful cabbage and the watercress. The gorgeous yellow blaze of a mustard field, as it flares amidst the sombre background of the Fens, must go to the credit of the order, as must the early Cuckoo-flower, which decks our meadows in spring, whilst country gardens would be very loath to spare the sweet-scented Wallflower (or, to stick to the old-fashioned name, Gilliflower), the bright Stock, and the Candytuft, the heads of which lead us back in thought to the Umbelliferæ.

Between the Crucifers and the Violets are arranged the Mignonette and the Rock Rose, two flowers that deserve some notice. The Mignonette tribe includes the Woad, with its memories of Cæsar and sky-blue-painted Britons, a costume which must have been far more picturesque than the modern top-hat and frock-coat. The Woad is also a historically interesting plant, for in the reign of Queen Elizabeth an ordinance was issued by the Privy Council, which had then far more power than it has now, forbidding it to be grown within several miles of London, because the Queen objected to the smell. Imagine Queen Victoria issuing such an order about cabbages! The Rock Rose is, to my mind, one of our most perfect wild flowers, and you may find it on almost any dry, chalky soil, a rather shrubby and hairy little plant, with large, bright yellow flowers in a cluster at the top, of the pure yellow which we found in the Rosaceæ, and reminding us much of that group, though easily distinguished by its narrow, strap-shaped leaves and its numerous stamens, as well as by the fact that there are usually several flowers on the stalk.

The Violets form, with the pansies, a well-marked and well-known group, and need no general description. Their great botanical interest lies in their double method of producing seeds. The open flower has five sepals and five petals, one of which has a deep spur filled with honey, to attract fertilising bees, and an ingenious arrangement of stamens and pistils in order to secure safe transference of pollen. For some reason or other, either because the flowers open before the bees are



WATER LILY.

coming round, or because they are specially suited to some species which is not often found in England, these flowers are often left unfertilised, though I think Mr. Step puts the case rather too strongly when he says that not one in a hundred succeeds. Still, one must agree that the plant is in need of another method to fall back upon, and it finds the way. After the bright flowers have fallen off, small buds which never open are produced, and in them are one or two stamens which shed a little pollen direct upon the enclosed pistil, and make sure of seed. The Wild Pansy, however, always seems to get on with its insect friends—perhaps because it flowers later—and it makes seeds by the first method only. One of the foreign violets, by the way, is respon-

sible for the production of ipecacuanha, a medicine that used to be a good deal more prominent as a remedy for all juvenile complaints than, happily for the juveniles, it is now.

Our last group includes the Buttercup tribe and the Water-lilies, and to it belong an extraordinarily varied assortment of plants, which set at nought all such ideas of strict adhesion to a conventional type as we found among the Crucifers. There is no fixed number, in many cases, ruling either petals or sepals, but they vary from flower to flower. Take, for instance, the Water-lilies which beautify our stagnant or slowly-running waters; you will find the freest possible arrangement, and you will also find that the petals, arranged in spiral curve, slowly fade into stamens, having forms on the border-line of change which seem to partake of the character of both. In the same way the thick fleshy sepals pass gradually into petals with no definite border-line between them. The raft-like leaves, anchored by long and tough stalks to the mud beneath, let one know at once where to look for the plant; but our English leaves cannot compare with those of the grand *Victoria regalis*, which spread to a diameter of over six feet, their edges turned up like those of an enormous tea-tray, whilst their splendid rose and white flowers measure as much as fifteen inches across.

Leaving the water-lilies, we come to the Crowfoot or Buttercup tribe, of which almost every individual has some striking feature. First comes the Wild Clematis, or Traveller's Joy, or Old Man's Beard, the long-feathered seed-vessels of which deck the hedges in autumn and winter. The greenish flowers (full of honey, as you will find it well to remember if you are a butterfly-hunter)

have only a calyx, and the corolla has changed all its petals into extra stamens. The plant climbs up its supporters by a unique method. It has no tendrils like the vine, nor does the stem as in the hop, but the leaf-stalks twist themselves around the neighbouring twigs and hold the plant firm.

The nodding Wood Anemone has also dropped its

WOOD ANEMONE.

petals, or changed them into stamens, but, as recompense, the sepals are delicately coloured. Pure white within, they are generally of a purplish pink without, and very rarely one may find them of a pale blue, like the Hair-bell. A more finely coloured species, for which we must go again to our chalk-downs, is the comparatively rare Pasque-flower, in which the sepals open out into a star

of the deepest violet, set off in the centre by a crowd of the characteristic yellow stamens of the order. Of the Crowfoots we have thirteen varieties in England alone, but they belong unmistakably to one group. The Water Crowfoots (two) are white, but the rest are of a brilliant shining yellow, the petals almost appearing to have been varnished in many cases. These petals, though five is the typical number, vary in an astonishing fashion. The Celandine, for instance, varies from seven to thirteen, the little Scarlet Adonis from eight to eleven. A word is due to the quaint little Winter Aconite, whose flower nestles, at the top of the stem, in the centre of a ring of finely-cut leaves. It is a doubtful native, but you may find it now uncultivated in many woods.

WINTER ACONITE.

The little Mousetail, which grows in dry cornfields, has a most ingenious method for securing pollen. At first flowering, the stamens are set in a ring on a level with the top of a spike, upon which are set a number of pistils. But as the stamens shed their pollen the spike begins to grow, and pushes the stigmas each in its turn against the pollen, until all have been fertilised and the spike stands far above the tiny flower, looking exactly what its name indicates.

The Globe-flower, which one most often meets in

gardens, but which is found wild in the mountains of the Lake district and Scotland, looks at first sight like a gorgeous double buttercup, but a closer examination will show that it lacks a corolla, and that its glory is given it by about fifteen overlapping golden sepals, which form a complete roof over the precious parts within. Moreover, as it depends upon large insects for cross-fertilisation, the overlapping prevents the entrance of ants, etc., which would only do harm. A big visitor, on the other hand, is enabled by his weight to get down to the honey and pollen and out again.

The Marsh Marigolds, which Shakespeare called King-cups, and which Oxfordshire "natives" used to call "Water-blobs," is a very similar plant in some ways. This also depends upon the bright golden sepals for attraction, having turned the petals into stamens, but the sepals usually number about five instead of fifteen.

The Hellebores are a very curious group, for, though they have both calyx and corolla, they are of most unusual relative sizes, for the calyx is large and spreading, whilst the petals have come down to a small ring of tubes just outside the stamens, containing honey. A good example is the Christmas rose, the pure white calyx of which you know, but for the corolla of which you have probably never even looked. You will find it, however, if you make a careful search around the stamens.

The last three types of the Crowfoot tribe are at first sight widely divergent, for they are the Columbine, the Larkspur, and the Monk's-hood. Though they cannot be called at all common in the wild state, you will have plenty of opportunity to study them in gardens, and if you pull off the petals and sepals and compare the essential organs with those of the buttercup, you will,

I think, realise the kinship that at first sight seems so distant.

The Columbine is marked by the fact that each of its five petals has a deep, back-running spur, filled with honey to attract insects, and the sepals are also brightly coloured, whereas the Larkspur is content with only one prominent spur, for which it has to thank a sepal. The petals are only two in number, and are reduced to mere honey-bags, or nectaries. The Monk's-hood is marked out at once by the curious topmost sepal, which is inflated into a kind of dome, covering the top of the flower, and containing within it the honey-bearing petals. As the bee comes to visit these, it is bound to touch the stamens lying beneath, and later on, when these have shed their pollen and curled back, to touch the ripe and sticky stigmas.

COMMON COLUMBINE.

CHAPTER XX.

INSECTIVOROUS PLANTS

HAVING thus rapidly glanced at our flowering plants in their botanical order, I want you now, as I warned you in Chapter I., to glance at three groups which we must pick out, not by their botanical relationships, but by some other peculiarity which they share in common. These groups are the flesh-eating plants, the parasitic plants, and the forest trees.

I cannot promise you here any marvels about dog-eating orchids, or plants that might devour men and boys. For information as to these, you must consult the instructive fiction of monthly magazines. Our plants in this chapter hunt humbler game, and are not even so ambitious as West Indian spiders, which are said to capture the tiny Humming Birds. Nevertheless, though on a small scale, the delicacy of their working is well worth the few pages I can spare them here.

There are two degrees of activity in insect-catching. In plants of the first class traps are constructed, but the plant does not move in any way to assist them. In the second, the plant actually makes more or less vigorous movement to ensure its successful capture of the unfortunate insect, or minute animal, that has been unlucky enough to be tempted to it. One word as to the object

of the capture. You may remember that nitrogen compounds are necessary to the formation of protoplasm. Now, some soils are not very rich in these, but animal substances are. Marshy soils are specially poor, and we shall find that almost all our examples of marsh plants live either in water or in bogs. Another curious point is that it is quite possible to overfeed a Sundew, for instance, with animal food, as you will probably find out if you ever keep a Sundew and feed it with flies, and the wretched plant dies painfully of indigestion!

As an example of the simple trap, let us take the Bladderworts, the pale flowers of which you may see lifted up above the surface of moorland pools, its few leaves floating level with the top, and its roots straying vaguely about in the water. On these roots are tiny bladders, measuring about a quarter of an inch in diameter, which you should examine under your magnifying-glass. You will find that at one of the lower corners there is a fringe of stiff projecting bristles, leading to a small trap-door in the centre of the fringe, which opens only inward. An inquisitive water-flea, voyaging possibly in search of food, or perhaps escaping from

BLADDERWORT.

ROUND-LEAVED SUNDEW.

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a pursuer, or perhaps out of pure curiosity, swims down the lane, guided by the bristles, and pushes against the trap-door. It lifts up easily, and our water-flea gets inside. But the valve shuts again by its own elasticity, and the edge rests against a cushion on the inner wall of the bladder. Now the visitor finds that the trap-door opens only one way, and swims about, trying to find another opening. There is no other, and the valve shuts so close upon the cushion that he can get no leverage to prise it open. In there he stays until, in a day or two, he dies, either from starvation or because the water, rendered foul by the lack of air dissolved in it, slowly suffocates him; and his corpse, with those of others who have joined him, or whom he found there when he arrived, is slowly digested within this tiny stomach of the plant.

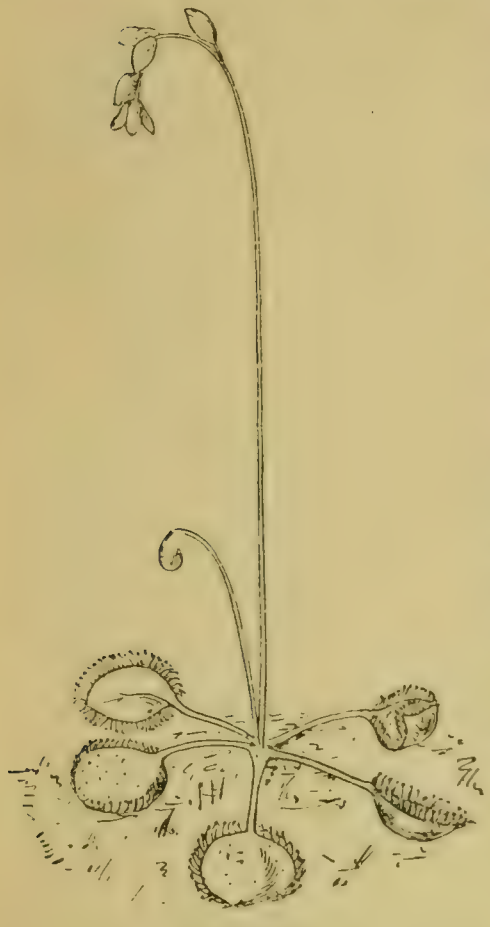
The Pitcher-plants one often used to hear of as a special provision of Providence for the sustenance of thirsty travellers in the desert, providing in their leaves a draught of refreshing water for the exhausted voyager. That they are a most wonderful device of Providence is true enough, but it was not in the traveller's interest, but in the plant's. In the first place, they are almost always to be found in spots where there is water already, and in the second, no traveller would want to drink from the leaves, for they are half-full of rotting insects, and the whole thing smells abominably, and looks like liquid manure. I cannot go into all the ingenious details here, for my business is with British plants, but the general principle is much the same in all. The pitcher-shaped leaves secrete honey along a line which leads to a precipice, and, once down, projecting hairs and other fortifications make the insect pretty sure of never coming back.

The unpleasant Toothwort, which we shall meet again among the parasites, is also an insect-catcher, not being content with the nourishment of which it robs the tree-roots selected as its host. Nine-tenths of its life is underground, for it only comes up to flower, and underground it lays its traps. Its thick leaves are doubly folded, and up this fold wandering insects crawl, to be enmeshed in sticky threads of protoplasm, which suck out their life and all their useful juices.

The Butterwort is a plant mentioned earlier as an ally of the Speedwells, and is a very prominent ornament of our mountains, recognised at once by its flat rosette of thick yellowish leaves, lying close to the earth, and by its beautiful flower, in colour and shape resembling a large violet. Our present interest lies with the leaves, and if you look at and feel them you will notice that they are covered with a sticky juice. If an insect alights on the leaf it is entangled in this juice for a moment, and thereupon all the glands on the top pour out both gum and also digestive fluid. At the same time the edge of the leaf begins slowly to rise and curl, either enfolding the visitor, or pushing him down to the central trough of the leaf, where he will be at the mercy of the full stream produced by the general activity. You will see at once that we have reached a more advanced stage, and the plant is taking an active, and not merely a passive, interest in the pursuit.

The last example we may consider is the Sundew, which you may find in marshes in many places, but especially in the bogs that one meets upon the lower slopes of our mountains. Here, again, we have a rosette of leaves, but these are not egg-shaped and sessile like the Butterwort's. They have a longish stalk, at the end

of which we find a round leaf, studded with bright-red hairs, on each of which glistens a tiny drop of sticky liquid. The flowers rise from the centre, a group of six or seven together in a loose panicle, all of a greenish white. If we place a dead midge or tiny fly (a bluebottle would be too much for the leaf and probably kill it) upon the leaf, and watch for a few minutes, we shall see a general movement of the hairs. They bend slowly over and hold the fly gripped in the gum. One after the other they curl inward upon it, until the fly is completely covered by them, and they set to work to digest it at their leisure. The sensitiveness of these tentacles you will realise when you know that a piece of hair weighing one fifty-thousandth part of a grain will bring them promptly round to bear upon it, and get what nourishment they can.



SUNDEW.

CHAPTER XXI.

PARASITIC PLANTS

In this chapter we shall briefly glance at the English examples of the great group of parasitic flowering plants. We need not here consider the Funguses, divided into the two sections of feeders on decaying and feeders on living organic matter, for they have been described in Chapter VII., but I want simply to draw your attention to three or four common English parasitic flowers that you may find any day upon your rambles, and which are well worth two or three pages.

And first I want you to recall the orthodox type of a well-behaved flowering plant. Its roots are sucking up moisture from the ground, and with the moisture they pick up dissolved mineral substances, such as sulphur, iron, etc., with various nitrogen compounds, all of which are required in their business. Meanwhile the leaves are busy breaking up the carbonic acid in the chlorophyll corpuscles, and the whole plant is breathing in at every pore the oxygen which the protoplasm requires to give it energy to do its work.

Now the parasitic plant declines to give itself all this trouble, and steals its brooms ready-made. (The name parasite, by-the-by, means one who feeds by the side of another, and was given by the ancients to the poor,

or greedy, people who fastened themselves on to a rich man in order to share his dinner, putting up for its sake with the insults and degradation that were generally experienced. The parasitic plant, however, gets the dinner, and, so far as we know, its unwilling host has not even the compensation of giving its candid opinion of its guest. At any rate, it cannot express it in ways that we can understand, and we only see the entertainer withering away.)

But there is a danger that we may be too sweeping in our condemnation and include in the list plants that are really getting their own living entirely. One sometimes, for instance, hears the Ivy spoken of as a parasite, but this is really quite undeserved. The Ivy may use a tree as a prop, but it never thinks of sinking wells into it, and robbing it, and is just as well off when it can find a friendly wall. On the other hand, it must be confessed that the tree is not by any means always so well off, for if the ivy is very fine and luxuriant, the supporting tree may easily be robbed of its fair share of light and air, and so practically be suffocated. In the same way, many tropical creepers bind so tightly around the trees up which they climb, that the trunk, as it endeavours to grow, is deeply furrowed by the twining bands of the creeper, which refuse to give way at all. On a small scale, you may sometimes see that an ivy stem has half-throttled a tree, and the honeysuckle not infrequently leaves marked traces. Still, this is not exactly parasitic, though very unpleasant for one party to the transaction. The distinction may be illustrated thus. If there is a stream running through two farms, one farmer diverts it all on to his own land and leaves his neighbour the dry bed. That is more or less the

part of the Ivy. But a parasitic farmer would adopt a different process. He would cheerfully let the stream run on, and encourage his neighbour to water his turnips well. But when they were just ready, he would slip in, and cart away half of them.

Having thus explained that certain plants are not parasites, we will consider those that can plead no defence. Of course it is possible to regard them really as the highest development of plant-life, employing the lower orders to do their work, but mankind has a well-founded prejudice against slave-owning, and one may note two facts about these parasites. In the first place, they are totally dependent for existence on other plants, and cannot under any circumstances fight their way unaided; and in the second place, they have generally lost some organs through lack of use. In the same way, if there were a country where people never stood, walked, or ran whatever happened, but always insisted on being carried, their descendants, if the habit were kept up for many generations, would in all probability lose, if not their legs, at least the capacity to use them.

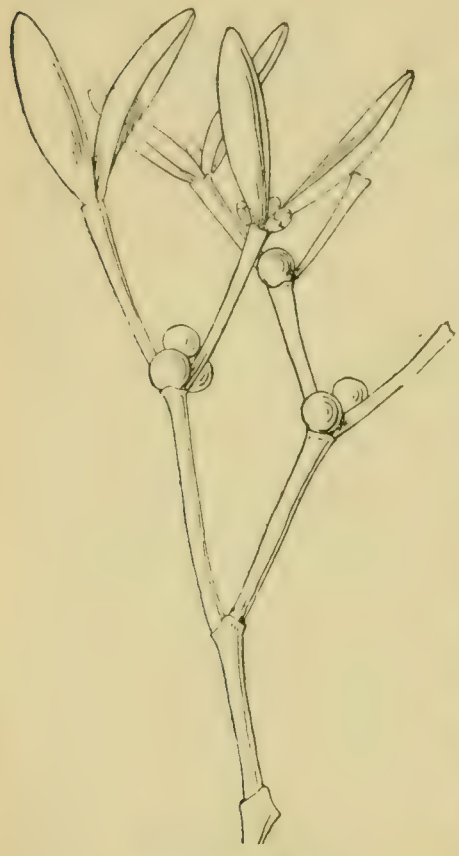
There are three degrees of the parasitic habit, in the first of which we find that the plant only takes a small amount of tribute from its neighbours. It still has roots and leaves, but the former, besides sending up their own supplies, take tribute from the roots near them. In the second class, all roots are abandoned, and the plant simply sends down suckers into the substance of the tree or plant on which it rests. But leaves are still kept, and do their work. In the third class the plants are wholly dependent on other resources than their own. Roots have gone, and leaves have gone, or, to put it more accurately, the leaves no longer perform their great duty

of breaking up carbonic acid. Instead we find them merely red scales enfolding the stem, if they are large, or just indicating where leaves once grew, and hardly noticeable with the naked eye.

The first class, of partial parasites, we noticed in Chapter XV., and it included the Yellow-rattle and the Eyebright. Their parasitic ways have not long been discovered, and the extent to which they carry them is still doubtful. Moreover, it is very likely that many more of our plants, when investigation is carried further, will be found not to be above this form of "parish relief," and at any rate it would seem that the giver of the nourishment suffers no perceptible harm. On the other hand, there is the curious fact that long before the charge was brought, the Swiss farmers called the little Eyebright the "Milk-thief," because, as they said, cows did not do so well on pastures where it grew. It will be intensely interesting, if records are still kept a thousand years hence, for observers to compare the habits of these beginners in robbery, and to see whether they have returned to honesty altogether, or, as I fear is more likely, whether they have given up their own ordinary root work entirely, and simply devoted themselves to sucking the life out of grass plants. One feels that a first cousin of the Germander Speedwell is really bound to return to respectable courses.

Our only English example of the second class, which retains green leaves but has given up roots, is the Mistletoe. Almost every tree is occasionally attacked by it. Perhaps the apple is the commonest in England, but in Germany the Black Poplar is generally chosen. In early spring, when it flowers, it is not very conspicuous, but when winter comes its gleaming white berries and its "golden bough" mark it out plainly enough. Although

it has leaves, they are much more closely allied to the stem in shape and colour than are those of most other plants, and it would not be surprising if they, too, lost what green they have before very long, and descended to the scaly state. Its life history is interesting, for it is one of the plants that are almost entirely indebted to birds for their distribution. The sticky berries are a favourite food of thrushes, which drop the seeds casually about when they sit down to rest. Part of the sticky berry is still sure to adhere to them, and if the bird was sitting on the branch of a tree, the seed will soon be anchored in some crevice of the bark. After a time a modified root, called a sinker, drives its way down until it gets to some cells with sap running through them. After that the growth is slow but steady. The main root runs along the top of the branch and sends down sinker after sinker, which go down like the teeth of a rake, gripping the bough in defiance of winter storms. Even if the main bush be cut off, these sinkers have energy enough to send out fresh shoots, and it is no easy matter to get the mistletoe out of an orchard in which it has once become established.



MISTLETOE.

The commonest pure parasite in England is the Dodder, which, in various species, may be found in the later summer almost everywhere. The most frequent is perhaps the Clover Dodder. If you walk over a clover-field in

HOLLY.

Face page 216.

August, you will occasionally come upon a patch that looks as if it had been dashed to the ground by a heavy shower. Look more closely, however, and you will see that the whole patch is entangled in the meshes of some plant with red, thread-like stems, at the joints of which are small balls of wavy, flesh-coloured flowers. There is no organised plant, but the general appearance is something like a skein of thin red wool with which an active kitten has been playing for half an hour. If complicated structure be the only test for a high class, the Dodder must come very low down, for the whole plant consists of these stem-threads and tiny flowers. Even the seed has become more simple. There are no seed-leaves, or cotyledons, but from the sprouting seed there comes a thread, twisted like a corkscrew, which lays hold of any growing stem near it, winds two or three coils around it, and rises with its growth, having no interest in the soil, for in that it cannot grow. The free end goes on twining and twisting, lapping fresh clover-stalks, if that be the luckless crop, and from the inside of each coil tiny suckers are driven into the soft stalk, looking under the microscope like the false legs you may see on the rear of two-thirds of most caterpillars. Not only clover, but furze, thistles, and nettles are subject to its attack.

DODDER.

Our last example, the Toothwort, is rather repulsive in appearance, for, in addition to its weird shape, it has a most unpleasant corpse-like colour. You may find it, not very commonly, upon the roots of the Hazel in April or May. That is to say, you will then see the upright

spike of flowers which the underground plant throws up. Beneath, its thick fleshy root, or stem, is plundering the hazel, while, as we said in the last chapter, it obtains its delicacies from the microscopic creatures that wander into the mazes of its closely-folded leaves. The Broom-rapes are of similar general appearance.

TOOTHWORT.

CHAPTER XXII.

THE FOREST TREES OF GREAT BRITAIN

In this chapter, as in the two preceding it, we shall have to deal with a single group selected on other lines from those which we have followed hitherto. Instead of looking to the flowers, and to methods of reproduction as the test of classification, we are now going to take the much simpler guide of *size*. Botanically, the elm and the nettle, the sweet-briar and the mountain-ash, have intimate connections, but from our present point of view we shall consider only those flowering plants which grow to great proportions. The reason why I emphasise this point is that I want you to realise that there is no sharp dividing line between our trees and the rest of the English plants. The Juniper, which we know as a bush merely, takes a more prominent place elsewhere, and so does the low-growing alder.

What I propose to discuss here is the outward appearance of those various trees of ours, and how you can tell one from the other, in winter and in summer.

First we will take the plants, or trees, which bear cones. In Chapter XI. we noted the chief characteristics of the various groups, but we will just go through them here again for the sake of completeness.

The true Firs are easily recognised by their leaves and

by their cones. The former are of the typical needle, or rather bayonet shape, with two edges, and white streaks upon the lower surface. The cone stands erect, and though the bracts and scales fall off, the main stem, or *axis*, of the cone, keeps fixed upon the plant. These scales are quite thin, an important character to bear in mind.

The Spruces are much like the Firs in general type, but the leaves are four-sided, and the cones hang downward as soon as the seed is fertilised.

The Larch is very easy to detect, for the leaves only cling to the tree for a year, whereas the rest of the family are all evergreen. The cones stand up straight upon the boughs, like those of the Firs.

Now the true Pines, of which, be it remembered, the so-called *Scotch Fir* is a typical representative, are marked by two features. The leaves are in groups, uniting, outside the branch, in a scaly sheath, which falls with them to the ground. The Scotch Fir has only two leaves in each group, but the other members, rarely seen in England, run to three, four, or five in a group. The Weymouth Pine, for instance, has five. The cones give a very easy clue, for the scales, instead of being thin and smooth, show a sudden thickening at the tip of each, which gives the cone a somewhat spherical shape.

This brief excursion over ground that we have passed before is all that we can spare for the conifers, and we must go on to pick out the trees that are included amongst those plants that keep their seeds enclosed in a case. So far as the Monocotyledons are concerned, this is not a heavy task, for in England they are like the famous snakes of Ireland—there are none. But this is, so to speak, a mere accident, for in tropical countries the

Monocotyledons figure very largely. The Palms, from various members of which class we get dates, oil, sago, vegetable ivory, and other useful products, form a very respectable contribution to forestry, and our tiny grasses have most opulent relatives. The Bamboo in Asia, and the many grass trees of the Australian Bush are all botanically in the same great division as wheat, barley, and oats.

The first of the dicotyledonous trees to be mentioned is the Elm, or rather the two Elms, which are to be found abundantly in England. They are the Common Elm, and the Wych, or Mountain, Elm. The former is much the handsomer of the two, growing to a very considerable height, and, in good soil, attaining a very regular outline. It is an easy tree to recognise at any time. In early spring, before the leaves appear, the whole tree is marked by a reddish hue from its flowers, covering the tops of the shoots, and these are soon followed by the clusters of seed-vessels, each seed inserted upon a flattened disc, greenish in colour, and almost giving the appearance of foliage at a distance. When these have fallen, the leaves are unmistakable for those of any other species. They have a curious eccentricity, for the two sides do not start from the same point in the leaf-stalk, but one leaves it a little higher than the other, though both terminate together at the point. The edge is *serrated*, that is, toothed like a saw, all along the margin. Finally, in the winter, one may recognise it by its rough, grooved bark, and by the tall curve

ELM LEAF.

of its general outline. The twigs are fine, and the branches divide freely, so that the edge of the tree stands out like a fringe against the winter sky.

To tell the Wych Elm from its cousin you may mark the lower and more spreading growth, the *doubly*-serrated leaves, and the position of the seed in its disc. This is exactly in the centre, whereas in the common variety it is well *above* the centre. Lastly, the leaf of the Wych Elm has a very short foot-stalk indeed, one side of the leaf almost reaching to the point of insertion on the twig.

The Common Plane tree requires a few words, for though not a native, it is very commonly cultivated,

PLANE LEAF.

and stands better than any of our native trees the smoke and dirt of large towns. This power of endurance is largely due to the peculiar habit which it has acquired of shedding its bark in large strips each winter, whereby it cleans itself to a great extent. The patchy appearance which results upon the smooth trunk is quite sufficient to

identify it when the leaves are gone. These are large, and divided into three lobes, but the divisions do not reach at all near to the mid-rib. The illustration will explain their shape more effectually than many words of description.

A large number of our trees belong to the catkin-bearing group, and the first of these is the Alder, for which we must look by river-sides and on swampy ground. Here, though it is generally rather bushy than tree-like, we may find solitary specimens growing to fifty feet in height. The leaves are of a dark green, and are almost circular. Instead of the mid-rib running out into a point at the far end, it fails to get quite to the circumference, and there is a slight depression at the top. Another test which may be applied is to break one of the twigs. The wood is white, but on exposure to the air soon puts on a reddish colour. In early spring both leaves and twigs are sticky, and in winter one may find old catkins still clinging, and all the budding catkins for next spring appearing upon the twigs.

Whilst the Elm may perhaps claim to be the handsomest of our trees, for pure grace of outline it must give way to the Birch. Upon the hillsides of Scotland it is to be seen in its perfection, but happily it is by no means confined to the North. In every county of England one may come across the gleaming silver bark, sometimes tarnished by black patches; the delicately featured leaves, and the ever-dividing twigs, the fineness of which is not easily surpassed. The leaves are somewhat like those of the Elm, but smaller and softer, and of a brighter green.

The Willow has been rather hardly treated by the cultivator, for nearly ninety per cent. have been

"pollarded," that is, have had the top shoots cut off from year to year, in order that they may crown their tops with a supply of osiers. But if they are allowed to grow naturally they make fine timber very rapidly, and are a great ornament to the landscape. With their sweeping branches, furrowed bark, and long narrow leaves of silvery grey, they deserve a fuller opportunity than is usually extended to them.

We have four poplars that are fairly common in England, the Black Poplar, the White Poplar, the Lombardy Poplar, and the Aspen. General opinion has specially applied the name to the rather melancholy "Lombardy," the tall spires of which are perhaps the first trees which one clearly identifies by name; but this is only a variety of the English Black, which has taken to pushing out all its branches erect. Dismal as a long avenue of these may, and does, look, there is no doubt that, judiciously planted amongst other trees, the poplar gives a pleasant variety.

The leaves of the black poplar are quite smooth on both sides, slightly notched at the edge, and more or less triangular, the angles at the base being somewhat rounded off. The White Poplar, on the other hand, is deeply notched, and can be recognised at once by a grey felty substance which covers the whole of the lower surface. The Aspen leaf, which has a very long foot-stalk, is smaller and nearly round, and, like the Black Poplar's, quite smooth above and below.

An interesting fact about the poplar is that it was chosen by the French Revolutionists, a hundred years ago, as the emblematic tree of liberty, which they planted everywhere on all possible occasions. The reason of their selection seems to have been based upon a "false

quantity," for they cheerfully assumed as identical in origin *pōpulus*, the Latin name of a poplar, which is feminine, and *pŏpulus*, the Latin name for people, which is masculine!

The Hazel, perhaps, hardly rises to the dignity of a tree, but we may seek a brief aid to its recognition. The stamen flowers form a long drooping catkin, whilst the seed-vessel is wrapped in the well-known involucre which surrounds the nut-shell. The leaves are oval, but have very distinct points at the end of the mid-rib. The margin is finely-toothed, and the general feature is rather coarse.

The Hornbeam also bears catkins and nuts, but the latter are not exactly edible. The leaf is longer in proportion to its breadth than that of the Hazel, and is not so finely toothed. In general appearance it is more like that of the beech, but the rough trunk distinguishes it. The leaves, moreover, cling to the parent tree for several weeks after winter has set in, and only quit their hold very reluctantly.

The Oak has two types commonly found in England. In one the acorns have long stalks and the leaves have hardly any, whilst in the other the acorns are very closely clustered, and the leaves have stalks of quite respectable length. The general shape of the tree is almost semi-spherical, whereas the elm, if well developed, is usually about two-thirds of an ellipse. The elm branches, moreover, are usually fairly regular, dividing into two equal parts, when they separate, whereas the main branches of a full-grown oak zigzag from side to side, like a flash of forked lightning. The leaves stay on till late, and their shape is, of course, unmistakable, for no other plant has foliage scalloped in quite the same way. The ragged

bark will complete the evidence if the tree is full-sized, but when it is only, say, one foot in diameter, this is not to be depended on as a means of identification.

The Beech is marked by the smooth bark of its trunk, and the clean, spreading limbs that are flung boldly out on either side. The leaves, smooth and very slightly scalloped between the lateral veins, put on most gorgeous colours in autumn, and a walk in October through Burnham Beeches can almost compensate for the loss of Canada's Indian summer. In winter one may find at the foot the bristling husk which hides the smooth, brown, three-sided seeds.

The Ash has one most striking and curious feature which it is useful to remember. The lower branches, after leaving the trunk, usually approach the earth, but at their extremity bend up to the sky again, following the outline of a curved pipe. With this clue, and remembering the thickness of the twigs, you will recognise the ash even without the aid of the compound leaf, with its seven or nine leaflets, or the tufts of winged seed-vessels, known as "keys," which often remain on the boughs until the following spring. You will not be surprised, if you compare the two carefully in their general way of growth, to know that the common lilac of the shrubberies is a close relation of the ash. The Mountain Ash is not really a relation at all, but is only another example of the misleading nature of many of our popular names. It is really of the same family as the pears and the apples, but the leaves are very like those of the Common Ash at first sight, and not very much attention used to be paid to the flowers. Its coral-red berries mark it out when the leaves and large flat heads of white flowers have fallen away.

SLOE.

Face page 226.

The Maple and the Sycamore may be taken together, for they have much in common. Both have five-lobed leaves, those of the Sycamore being slightly serrated as well. Both also have two-lobed fruits, provided with wings. Besides the difference in size—the Maple is quite a small tree—one may note that the Maple's cluster of flowers is erect, the Sycamore's drooping; the two wings of the Maple seeds are almost in a straight line, the Sycamore's curved into a U, with the seeds at the base. The Maple is also noted for its very rugged and corky bark. The Sycamore honey appears to have a fatal fascination for bees, for when the tree is in flower, they may be found beneath it in a state of disgraceful and hopeless intoxication.

The Lime has a fairly smooth trunk and a general outline much like that of the Elm, but the twigs are not so finely divided, and there is less regularity in the branching. The leaves are heart-shaped and slightly toothed. The flowers and seeds have been described already.

Although this chapter is of British trees, one must say a word or two upon the Horse-chestnut, which was introduced in the sixteenth century to England. The earliest leaf to fall at autumn is the five-fingered foliage of the Horse-chestnut, but it is also one of the earliest to welcome the coming of spring, and one may thank the introducer with sincerity for the towers of pink and white bloom and the glossy brown seeds. In winter, its rather coarse branches and twigs, and the swelling buds at the end of the latter, save us from confusing it with any other species.

CHAPTER XXIII.

COLLECTING

I MUST confess I am half inclined to open and conclude this chapter with the words "*Don't collect*," but then one reflects that after all there are two methods of collecting, one of which is valuable and the other detestable. The man or woman, or boy or girl, who digs up a rare plant or fern when found, and carries it off, either to plant it in some garden, or to press it for his store, deserves to sleep on stinging nettles, for, if left, it might grow and multiply, and give pleasure to hundreds. On the other hand, it is legitimate enough to carry off the flower, for the plant will produce more, and with it the characteristic leaves necessary to make sure of its identity. *Never* carry away a plant which is either beautiful or rare; those that are common and ugly you will not wish to. You may argue that the root is also important, sometimes, as in the bulbous buttercup. Well, there are plenty of buttercups, so one root may be conceded to your scientific interest; but if the plant is rare you must leave the root alone as sacred. The trowel is as unsportsmanlike a weapon for the amateur plant-hunter as a gun for a fox-hunter. You can get all your pleasure without it, and leave more for other people. If you want to try botanical experiments, and need whole plants,

I recommend the Dog Mercury. No one would notice the difference if every youthful botanist in England commandeered a supply of twenty.

On the other hand, unless you make a systematic business of your plant-hunting, you will not get half the possible pleasure out of it, and one plan which has both interest and use is to make a yearly list of the plants you can find in any given district. If you are at home all the year the thing is simple enough, but if you are at a boarding-school it is quite worth the trouble of making a double list, for the Flora of the two places will probably be quite different. If you keep it from year to year you will find an added interest in the way in which flowers disappear from a neighbourhood and fresh flowers come in. More curious still, you will notice how certain flowers appear in great abundance one year, and the next task all your powers to find a specimen. If you start, say, on January 1st, one of your earliest discoveries may be, perhaps, the Whitlow Grass, on some sheltered wall or bank. Its four small separated petals and sepals warn you to look for it in the *Cruciferæ*. Then, in a previously ruled book, you mark it down.

English Name.	Latin Name.	Order.	Place.	Date.
Whitlow Grass (Vernal)	*Draba verna*	*Cruciferæ*	Shotover	10/1/99

Do not mind putting down the Latin names. They will be useful afterwards, and in time you will remember them. For complete equipment all that is wanted is an ordinary botanical tin, a stout pair of boots, and a wholesome liking for mud.

But we have perhaps been a little premature in starting at the making of the list, for we have first to capture our

flowers. Almost all sorts of country have their special glories, but the greatest variety is to be found in four places: marshes, especially those which have also a definite slow-running stream through them; the skirts and the ridings of woods; anything in the way of a ruin, from a castle to a cowshed; and a fallow field. The last is not very common, even in these days of agricultural depression, but is very profitable. Disused chalk-pits or gravel-pits and railway cuttings are by no means to be despised. You may reckon 250–300 a very good score for any district in one year, if you do not include grasses, but they are well worth the trouble of making out, and should not be neglected.

The next point is, of course, to discover what you have captured, and Johns' *Flowers of the Field*, backed up in difficult cases by Bentham and Hooker, should solve almost all your problems. When these fail, one can generally find some enthusiastic amateur in the neighbourhood who has made plant-hunting his hobby, and is always glad to help.

Remember, for one thing, always to gather a root-leaf as well as a stem-leaf, for they often differ greatly; and, for another, to get everything into water at once upon your return, for a withered flower is very hard to recognise. Do not be content with simply lumping a doubtful individual into a general class of "trefoil," "parsley," or "hawkweed," but thrash the matter out to the very end.

Next, as to their preservation. The apparatus is simple. A dozen sheets of good blotting-paper, which must be changed if they get damp or stained, a couple of boards and a band to go round the whole are all that is necessary. An ordinary linen press is useful to put the whole thing

in, but beware of too enthusiastic pressure on the lever. You do not want to drive the flower into the blotting-paper, and merely require that the whole thing shall be sufficiently tight to keep the plant from shifting. The arrangement of the plant on the paper is merely a matter of infinite patience. You cannot hope that the colours will be preserved. Flowers are not like butterflies, which will retain all but the supreme freshness of their bloom for many years. We must be content to see red, white, and many blues resolve into a blackish hue, though yellow is more persistent. It is a good thing, if one has the skill, to paint on the mounting-sheet the living colour of the specimen. This mounting-sheet should bear upon it, with the flower, the particulars upon the original list, and it is a good rule that each sheet should bear examples of only a single *genus*.

The very fleshy-leaved plants, such as the Stonecrops and Houseleeks, are a serious difficulty. The best way is to slice both stem and leaves, and scoop away the juicy part before putting them into the blotting-paper. I have read that they may be admirably preserved by baking them in sand, but I must confess that my own experiments in that direction were lamentable failures. Still, I recommend you to try it, for the sake of experience, and I wish you success.

The best way of mounting is to paste thin slips of gummed paper across the stems, and over each cartridge sheet should be gummed from the top a covering flap of thinner paper.

Now that photography is so common, excellent work can be done with a small hand-camera, and the snap-shots are often far more recognisable portraits than the withered originals when they escape from the blotting-

paper. If you are lucky enough to be able to draw, you should need no advice to use your invaluable powers.

The last word I have to say in this little book, if any of you have accompanied me to the end, is simply to repeat what I have said more than once before: "Use your magnifying-glass constantly, and see things for yourselves."

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